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A Study on the Effect of School Bag Weight on the Step Length in Children Aged 11-15 Years

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Abstract
Background and Objectives: School bags are an essential part of daily school life; however, carrying excessive loads may influence gait parameters and contribute to musculoskeletal strain in children. Step length is an important spatiotemporal parameter of gait that reflects walking efficiency and stability. This study aimed to investigate the effect of school bag weight on step length in children aged 11–15 years.
Methodology: A comparative study was conducted among 80 school children aged 11–15 years. Step length was measured under two conditions: walking without a school bag (0% load) and walking while carrying their school bag (100%). Participants walked on a 5-meter walkway at a self-selected speed, and step length was recorded over three trials for each condition. The average step length was calculated, and a paired sample t-test was used to compare the two conditions.
Results: The mean step length without carrying a school bag was **62.5 ± 9.54 cm**, whereas the mean step length while carrying a school bag was **61.4 ± 10.95 cm**. The paired sample t-test showed a mean difference of **1.11 cm** with a **t-value of 1.22** and a **p-value of 0.224**. Although a slight reduction in step length was observed during load carriage, the difference was not statistically significant.
Conclusion: The findings indicate that carrying a school bag resulted in a small decrease in step length among children aged 11–15 years; however, this reduction was not statistically significant. Therefore, under the conditions of the present study, school bag weight did not significantly affect step length. Further research with larger samples and comprehensive gait assessment is recommended.

Keywords: School bag weight, Step length, Children, Walking biomechanics

INTRODUCTION

The early school years are a vital developmental era in which children learn to carry school backpacks on a regular basis. These loads frequently comprise not only textbooks and notebooks, but also stuff for extracurricular activities like sports clothes and computer equipment. As educational needs grow, so do the quantity and weight of school supplies, resulting in bigger backpacks.[1]
It is important to assess the biomechanical impact of backpack weights, particularly in children. Gaining insight into how various load levels influence walking patterns and foot mechanics can help shape preventive measures and ergonomic recommendations.[1]
More specifically, children aged 11 to 15 are seen as especially at risk because younger age groups, due in part to growth spurts, may be more likely to have maladaptive reactions in soft tissues when exposed

to heavy loads.[2]

Research has indicated that carrying loads can affect gait kinematics, ground reaction forces, and plantar pressure. The changes in static or dynamic posture resulting from load carriage may lead to musculoskeletal injuries. However, it remains uncertain what other biomechanical and motor control alterations might take place in gait. Consequently, there is increasing concern regarding the potential impacts of load carriage on gait biomechanics and motor control strategies[3] It was noted that the typical weight of loads carried by children was 5.3 kg, which is about 10% of their body weight. Even though the average weight of school bags Based on the suggested guideline for load limits, which is 10% of body weight. 50% of students were still found to have bags that exceeded this weight. There was a significant connection between the carried loads and the observed outcomes.[4]

Walking, or human locomotion, is the forward motion of the body accomplished by the coordinated rotation of its components. The head, arms, and trunk (HAT) are efficiently supported and propelled by the rhythmic movements of the legs. About 75% of the whole body weight is made up of HAT, with the trunk making up the remaining 50% and the head and arms making up about 25%.[5]

To enable a thorough explanation, comprehension, and study of the events occurring, gait can be divided into segments. A gait cycle is made up of two consecutive instances of the same limb, usually indicated by the lower limb's first contact with the ground (also called heel contact or heel strike). Each limb has two main phases during a single gait cycle: the stance phase, which lasts for around 60% of the cycle and consists of a portion of the foot in contact with the ground, and the swing phase, which lasts for the remaining 40%.[5]

A rudimentary analysis of gait can be obtained by measuring time and distance, two essential components of motion. Stance time, single-limb and double-support time, swing time, stride and step time, cadence, and speed are examples of temporal factors. (Fig.1) Stride length, step length and width, and toe-out degree are examples of distance variables. (Fig.2) These factors, which were developed through seminal studies carried out more than 30 years ago, offer vital quantitative information about a person's gait and have to be incorporated into any gait evaluation. Age, sex, height, body composition, the distribution of mass in body segments, joint flexibility, muscular strength, style of clothes, footwear, habits, and psychological state can all have an impact on each variable. Nevertheless, not every element affecting gait will be covered in this article.[5]

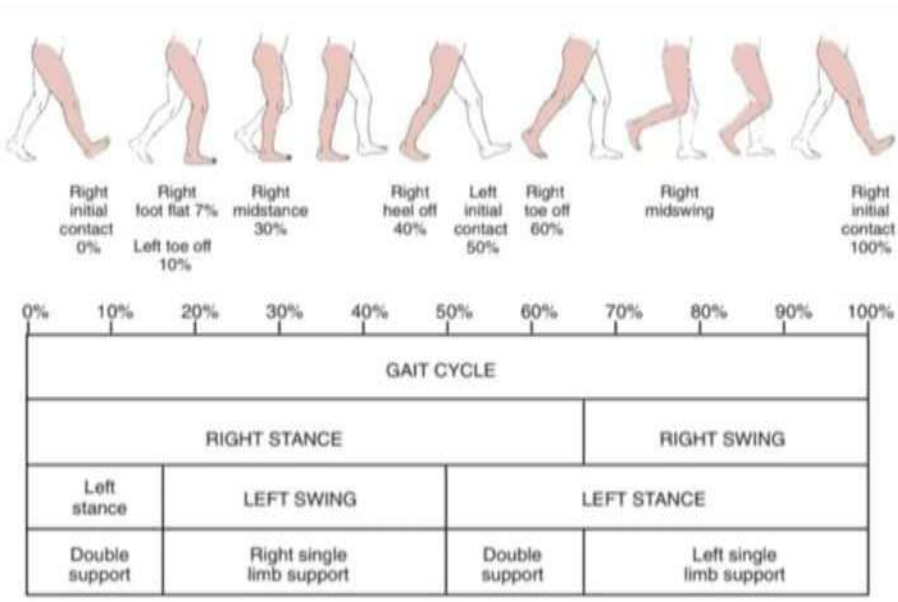

Fig.1 A gait cycle spans the period between initial contact of the reference extremity (right) and the successive contact of the same extremity. This figure shows the gait cycle with major events: stance phase and swing phase for each limb and periods of single and double support. The stance phase constitutes 60% of gait cycle, and the swing phase constitutes 40% of the cycle at normal walking speeds. Increases or decreases in walking speeds after the percentages of time spent in each phase.[5]

The straight-line distance between two consecutive points of contact between opposing feet is referred to as step length. It is usually measured from one foot's heel strike to the opposite foot's heel strike (Fig. 2). Gait symmetry can be understood by comparing the step lengths of the left and right foot; the more symmetrical the gait seems, the closer the step lengths are to one another. When the ratio of step length to step rate hits about 0.006 m per step, or an individual's optimum walking speed, step length variability is at its lowest.[5]

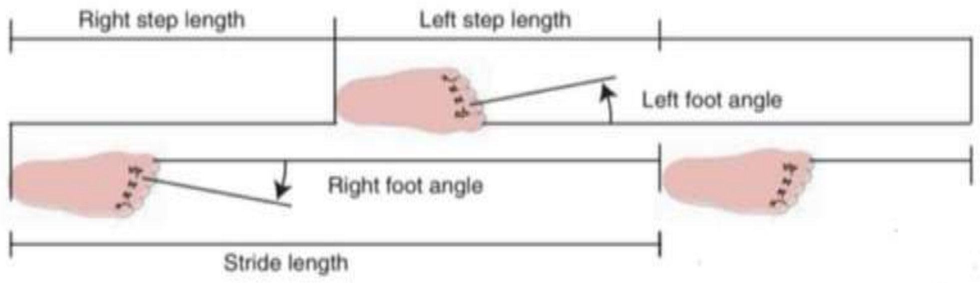

Fig.2 Stride length, Step length, and width shown with foot angle placements. The midpoint of the heel is used as a point of reference for measuring step width.[5]

The manner in which children carry their backpacks is a frequently debated topic. Using both shoulders for support with a backpack is linked to less discomfort, decreased pressure sensation, improved stability, and easier mobility. Children should refrain from carrying backpacks asymmetrically, particularly on just one shoulder. The method of transporting the load is influenced by various factors, including the shape and weight of the contents, duration of transport, environment, and individual physical and mental conditions. Postural issues resulting from backpacks can be exacerbated by the presence of obesity or excess weight among school-aged children. Typically, children might opt for a two-strapped backpack, a one-strapped backpack, a suitcase, a satchel, or a wheeled schoolbag. The kind of school bag affects the incidence of pain, discomfort, postural problems, and the ergonomics of movement.[6]
Research examining joint kinematics and kinetics has indicated that healthy older adults exhibit changes in joint kinematics and kinetics that continue regardless of variations in gait speed, such as reduced peak hip extension angles, lower plantar flexion kinetics, and diminished plantar flexion at toe-off. However, it remains unclear how age and sex interact to influence gait performance in asymptomatic adults, as well as the significance of considering age when selecting control participants in clinical gait studies focused on kinematic and kinetic outcomes.[7]

The purpose of this study was to examine how carrying backpacks with varying weights affects the movement patterns and forces involved in walking among school children. It was suggested that as the load increases, both the mechanical load and the spatiotemporal characteristics of gait also change.[8] In a significant change in spatiotemporal parameters such as stride length, cadence, duration of the swing and double support phases. However, reported that the backpack load increased may be decreases or increase a step length and speed of walking.

OBJECTIVES

Objectives

This study aims to assess the seriousness of the issue related to heavy schoolbags by measuring their weights, investigating the reasons behind the guideline to maintain them at or below 10% of a child's body weight, and examining children's reports of discomfort, pain, and investigate gait parameters like step length.

Review of Literature

Review of Literature

1. **Bridget Grobler and Mark Kramer**; et al (2023) conducted study on ; the Acute Effects of Schoolbag Loading on Posture and Gait Mechanics in 10- to 13-Year-Old Children. A total of 60 participants in the 10 to 13 year age range volunteered for the present study. Significant differences were evident for relative load carriage, forefoot. Those who exceeded 15% BM were ~ 9 times more likely to report pain than those below 15% BM loading leads to acute changes in posture and gait that are likely not meaningful.[2]
2. **Paulina Tomal, Anna Fryzowicz, Elzbieta Skorupska and Lechosław B. Dworak.** et al (2022) conducted study on Influence of School Backpack Load as a Variable Affecting Gait Kinematics among Seven-Year-Old Children. They have included 26 primary school children aged 7 years. The children walked at there preffered speed, under 4 condition: with no load (0% BW) and with 10%, 15% and 20% body weight. Spatiotemporal parameters were measure using the 2m Footscane platform system and photocell Sectro timing system. In the presented study, increasing the additional external load was shown to influence the spatiotemporal gait parameters this changes indicate that increasing the BP load changes the step length, width and time single and double support times and velocity. The analysed parameters mostly differed with BP loads between 15% BW and lower external loads as well as between 20% BW and lower external loads in both gender group.[6]
3. **Karzan Noori Saleh, Abdulrahman Khaleel Suliman, Goran Noori Saleh**, et al (2024) conducted study on Impact of backpack weight on students in primary schools. The study's participant's were 350 kids, whose ages range from 6 to 11 yrs a total of 200 males and 150 females from all grades level who walked with rucksacks were randomly selected to take part in the study. The bag to body weight ratio was considerd. A considerable number of student (69%), impacted mostly on the shoulders and neck ($p<0.005$), experienced musculoskeletal complain in the first and second sessions as a result of carrying heavy luggage.[9]
4. **Kateřina Jenčíková1, Mario Kasović and Martin Zvonař**, et al (2024) conducted study on The effects of school bag load carriage on gait kinematics in children: a school-based study. 221 children (124 girls and 97 boys), aged 9.5 ±

2.1 years, were randomly selected from three primary schools in the city of brno, Czech republic. Gait analysis without and with the school bag carriage was performed using the zebris pressure platform. The softwear generated the data for partial and temporal gait parameters. The mean school bag weight was 4.86 ±
1.21 kg repeated measures ANCOVA adjusted for sex and age showed that carrying a school bag resulted in a higher external left foot and right foot rotation narrow step width, longer left foot and right foot step time, longer stride time, less cadence and slower gait speed. Carrying a school bag weight may change gait characteristics in school going children specially in temporal parameters.[10]

5. **Rabiya Husain and Dhananjoy Shaw**. et al (2025) conducted study on Influence of varying backpack loads and selected carrying durations on time elapsed between first and second peak forces of walking gait of school-going boys. 85 boys (aged 10-12 years) from the national capital territory of Delhi participated. Temporal gait parameters were measured under five backpack conditions and five carrying durations. Increasing load and duration significantly prolonged the interval between FPF and SPF indicating an extended midstance phase. At 15% - 20% body weight, compensatory gait mechanism began to fail, leading to longer intervals and greater variability, suggesting biomechanical strain and reduced walking efficiency. backpack weight and carrying duration markedly influence temporal gait parameters, particularly the FPF – SPF interval.[11]
6. **Cazmon Suri, Iman Shojaei, Babak Bazrgari**. et al (2020) conducted study on Effects of school backpacks on spine biomechanics during daily activities: a narrative review of literature. A total of 1159 people of aged 7 to 27 years were included in study. The added load of a backpack and the changes in spinal posture when carrying a backpack. The findings included results related to the effects of backpack weight and position on trunk kinematics and spine posture as well as trunk muscle activity during upright standing, walking, and ascending and descending stairs. Although the reported alterations in trunk muscle activities and lumbar posture are indications of changes in the active and passive response of the lower back tissues, the resultant effects on spinal load, that is, an important causal factor for low backpain, remains to be investigated in the future. A knowledge of backpack-induced changes in spinal loads can inform design of interventions aimed at reduction of spinal load via improved backpack design or limitation on carrying duration.[12]
7. **Grimsha PN, Marqus – Biuna P, Salo A**. et al (1998) conducted study on three dimensional kinematics of the walking gait cycle of children aged between 10 and 24 months: cross sectional and repeated measures. The purpose of this study was to examine the 3-dimensional kinematics of 'normal' walking gait in young children. The children were at different stages of walking development. Repeated measures were taken from two of the children at 10 and 17 months of age and then at 18 and 24 months respectively. The position and movement of the arms were identified as potential motor development patterns. Ranges of movement and motion patterns observed in other variables are useful to determine 'normal' walking gait in such young children. The knees and hips were flexed throughout the gait cycle. Inter-limb asymmetries were observed for the knee angle pattern and for the stance and swing phase time. The mean stance phase time and double support time were 4 and 15% (respectively) greater than in adult's gait.[13]
8. **Van der Linden ML, Kerr AM, Hazlewood ME, Hillman SJ, Robb JE**. et al (2002) conducted study on Kinematic and kinetic gait characteristics of normal children walking at a range of clinically relevant speeds. data were obtained from 36 normal children who walked at five different

clinically relevant speeds, which were mostly slower than normal speed. Speed groups were normalized for body height. Speed significantly affected most of the stride parameters, joint angles, joint moments, and the ground reaction force in all three planes of motion. The effects of speed were not always the same over the whole range of speeds studied. The clinical relevance of these findings is that when comparing pathologic gait characteristics with those of normal children, these should be derived from the same walking speed. This may help to differentiate between effects caused by speed and underlying pathology.[14]

9. **B W Stansfield [1], S J Hillman, M E Hazlewood, J E Robb**. et al (2005) conducted study on Regression analysis of gait parameters with speed in normal children walking at self-selected speeds. Dimensionless analysis ensures that differences in sizes (e.g. height and weight) of children have a minimal influence on gait parameters. The results of changes in speed on gait parameters were examined using dimensionless analysis on data from a prospective 5-year study of 16 children. Linear regression analysis of peak and trough values of temporal distance parameters, ground reaction forces, joint angles, moments and powers provide a quantitative description of gait development with normalised speed. These linear relationships can be used to estimate gait parameters from speed measurements for normal subjects. However, caution is advised in using the data to attempt to predict an individual's gait parameters due to the wide spread of data about the regression lines and we do not recommend that the data be used to extrapolate the regression data to wider speed ranges.[15]

Research Methodology

Study design

This study was a **Comparative study** using a **within-subject (repeated measures) design**. Each participant was assessed under different school bag load conditions to determine the effect on gait characteristics, specifically step length. The study was conducted in a selected primary school. A flat, straight **5-meter walkway** was used for gait assessment to ensure consistency.

Participants

A total of 80 primary school children aged 11-15 years were recruited for the study.

Inclusion Criteria

- Children aged between 11-15 years
- Both Boys and Girls were included and they were healthy participants

Exclusion Criteria

- History of musculoskeletal or neurological disorders
- Recent lower limb injuries or pain
- Any observable gait abnormality

Sampling Technique

Participants were selected using convenience sampling from the chosen school.

Variables

Independent Variable

- School bag load as a percentage of body weight:
  - 0% (no load)
  - 100% (heavy load)

Dependent Variable

- Step length (measured in Centimeters)

Subject

A study on the effect of school bag weight on step length in children ages 11-15 years. The study adhered to strict ethical guidelines, ensuring voluntary participation, confidentiality and the right to withdraw at any time. Participation who did not meet the age or health criteria, or who withdraws during the study, was excluded.

Instruments and Materials :

- Weighing scale (to measure body weight and bag load)
- Stadiometer (to measure height)
- Plastic Tray filled with Water
- Measuring tape (to measure step length)
- Standard school bag
- Chalk sticks
- Plastic Scale

Procedure:

The participants were gathered in the school ground or hall. Prior to data collection informed consent and release of liability forms was obtain from the participants. The entire data collection procedure was thoroughly explained to the participants to ensure they understood the process. The height and body weight of each participant was recorded. The weight of school bag of each participant was recorded. Each participant was asked to walk along a **5-meter walkway** at a comfortable, self-selected speed under two conditions: Without school bag (0% load) and With school bag (100% load). The participants wet their feet in the water and walks normally, they did it for 3 trials. Then, the participants wet their feet in water and walks while carrying a school bag, again for 3 trails. In each trial we had taken a one random step length in **5-meter walkway**. Three trials were conducted to take a step length in each varient, and the average value of Step Length was taken. A rest period of 2–3 minutes was provided between trials to prevent fatigue. Step length was measured as the distance between successive heel contacts of opposite feet and recorded in centimeters.

Measured Step Length with or without school bag

Figure 1: shows that the student is filling the consent form with the guidance of therapist

Figure 2: Shows that the therapist is assessing the height of the student

Figure 3: Shows that the therapist is assessing the weight of the student

Figure 5

Figure 6

Figure 7

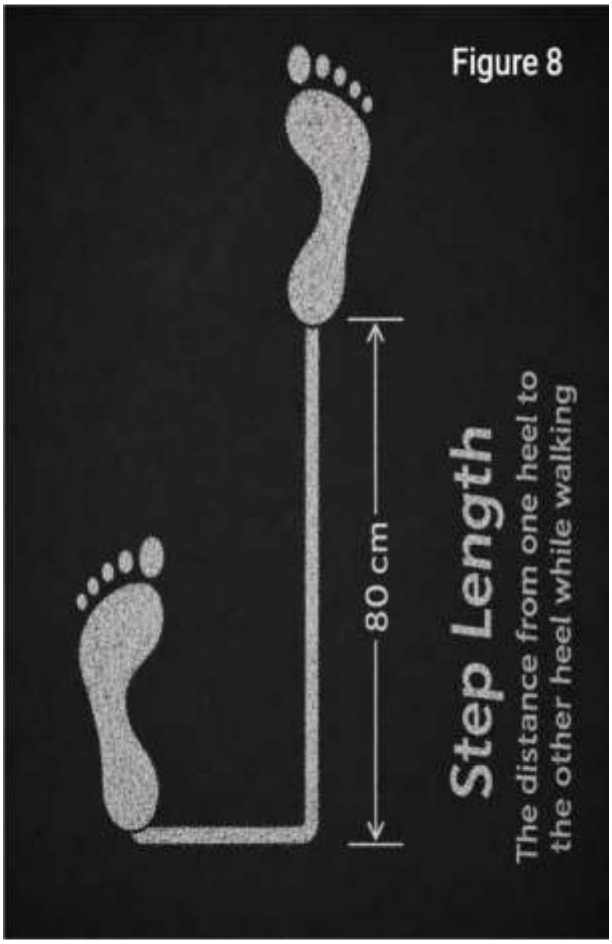

Figure 5, 6, 7 and 8: Shows the process of measuring the step length of student with 0% load of school bag with the consecutive 3 trials with the same.

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Figure 9


Figure 10


Figure 11

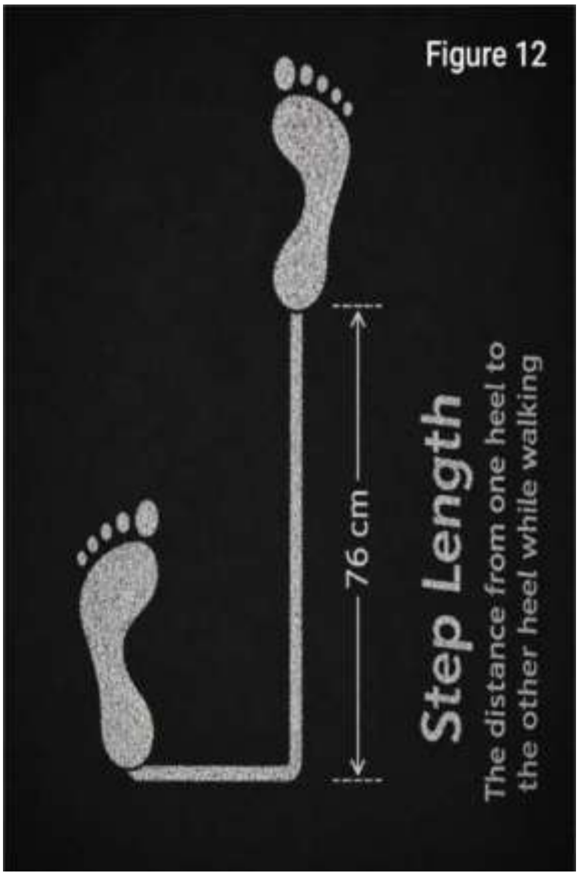


Figure 9, 10, 11 and 12: Shows the process of measuring the step length of student with 100% load of school bag with the consecutive 3 trials with the same.

Data Analysis

jamovi 2.7.24 was used for data analysis. A total number of participants were 80 Students. Amongst them 47 Boys and 33 Girls were included in our study. We have taken the students of age 11-15 yrs.

Table No: 1 The Mean difference and Standard deviation of Age, Height and Weight.

Variables (N=80)	Mean Difference	Standard Deviation
Age	13.15	1.35
Height	153.08	11.23
Weight	41.91	11.49

Table No: 2 Mean difference and Standard Deviation of School Bag Weight.

Variables (N=80)	Mean Difference	Standard Deviation
School Bag Weight	6.07	1.21

Table No: 3 Comparison of step length with and without school bag weight.

Variables (N=80)	Mean Difference	Standard Deviation
Step length without bag (0% load)	62.81	9.54

p length with bag (100% load)	61.73	11.01

Table No: 4 Paired sample t-test for step length with bag and without bag.

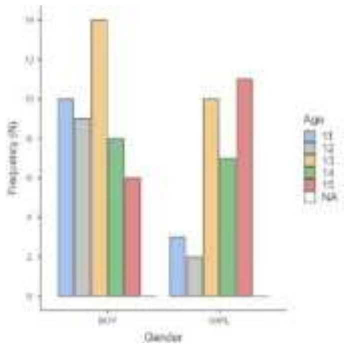
Comparison	**Mean Difference**	**t-value**	**df**	**p-value**
Step Length with bag and without bag	1.08	1.196	79	0.235

From data analysis, carrying a school bag resulted in a slight reduction in step length; however, the difference was not statistically significant and showed a very small effect size. Therefore, school bag carriage had minimal impact on step length among the participants.

A correlation graphs are showed below with the correlation of our questionnaire with the step length with (0% load) and (100% load)

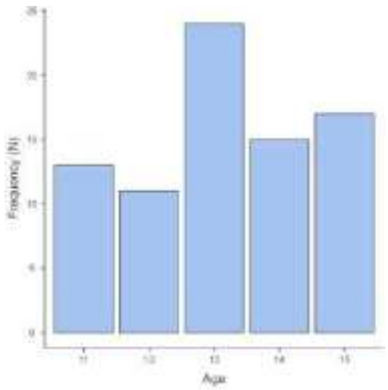
Graph no: 1.1 Histogram of Age Vs Gender

The graph shows the distribution of male and female participants across different age groups. Participants were fairly distributed among the age categories, indicating adequate representation of both genders.

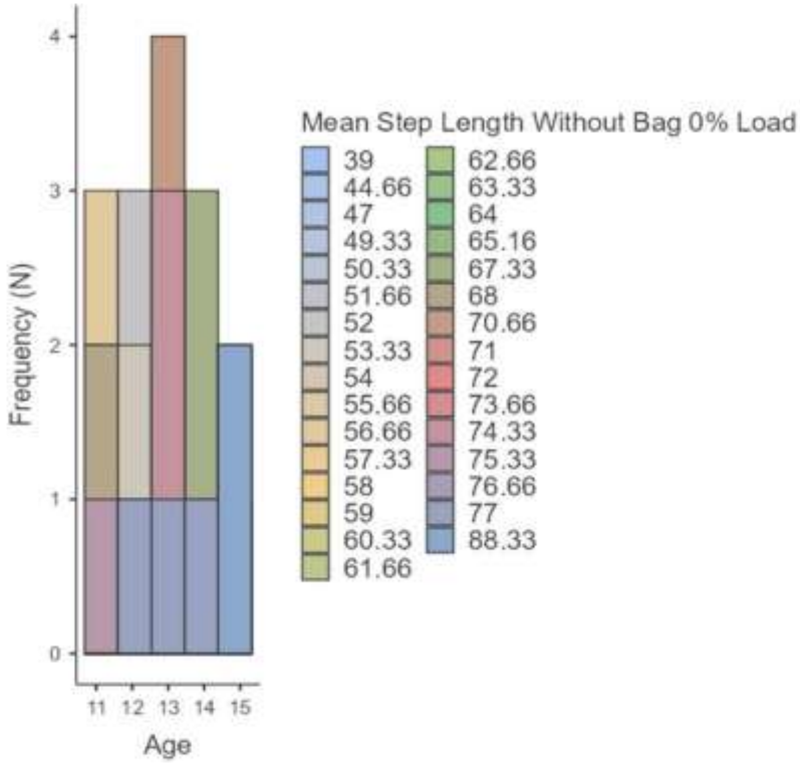


Graph no: 1.2 Histogram of Age

The graph illustrates the age distribution of the study participants. Most participants were concentrated within the middle age groups, reflecting the target population of children aged 11–15 years.

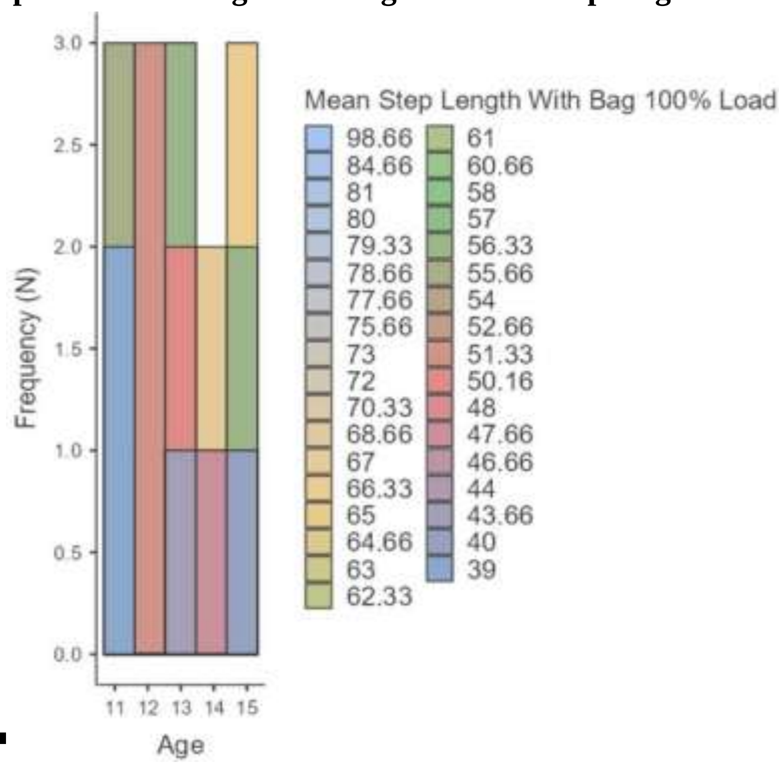


Graph no: 1.3 Histogram of Age Vs Mean step length without Bag



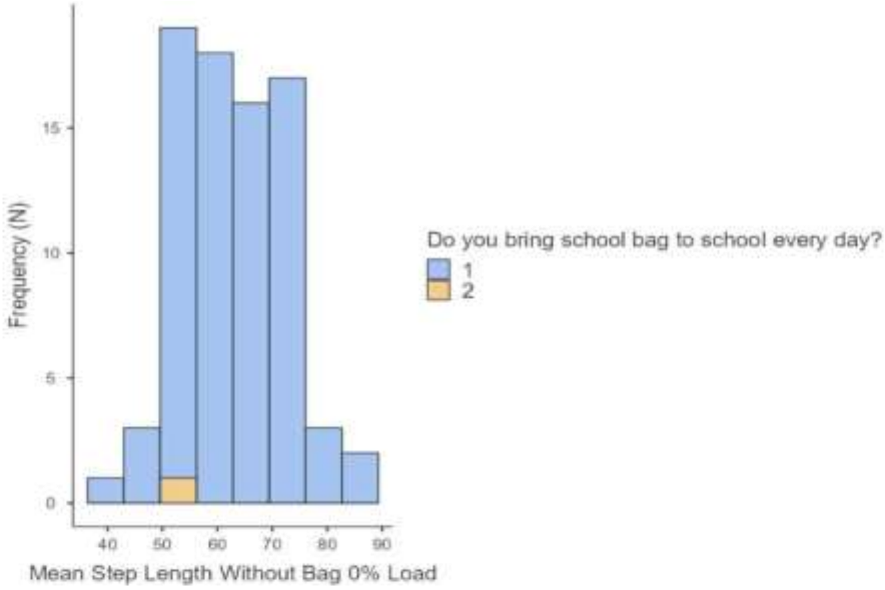
The graph demonstrates a positive relationship between age and mean step length in the unloaded condition. Older children generally exhibited longer step lengths than younger children, which may be attributed to increases in height, lower limb length, and musculoskeletal development with age. This finding reflects the normal maturation of gait patterns in children aged 11–15 years.

Graph no: 1.4 Histogram of Age Vs Mean step length with Bag



The graph shows that although step length increased with age, the presence of a school bag resulted in a reduction in step length across all age groups. This suggests that school bag carriage imposes an additional mechanical load that alters gait irrespective of age. The reduction may represent a compensatory strategy to improve stability and reduce energy expenditure during loaded walking.

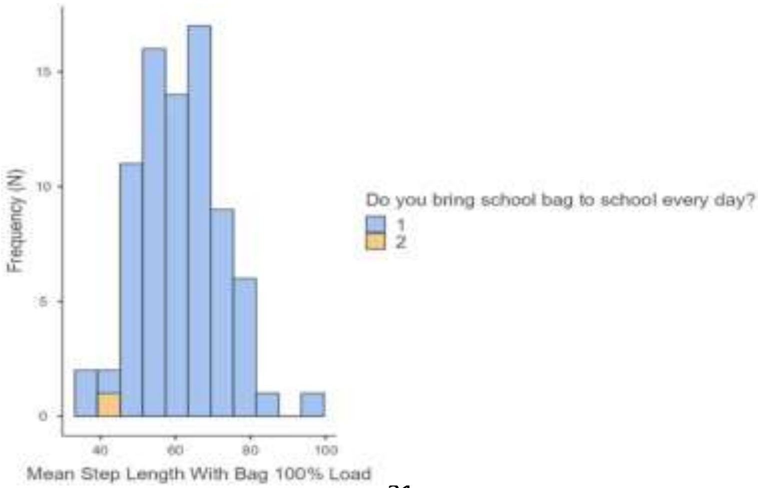
Graph no: 1.5 Histogram of Mean Step Length Without a School Bag According to Whether the Child Brings a School Bag to School Every Day



Here, 1 indicates Yes and 2 indicates No.

This graph shows, Approximately **98–99% of participants** reported bringing a school bag to school every day, whereas only about **1–2% of participants** reported not bringing a school bag daily. The mean step length without a bag was predominantly distributed between **50 cm and 75 cm**, with the highest frequency observed around **55–65 cm**.

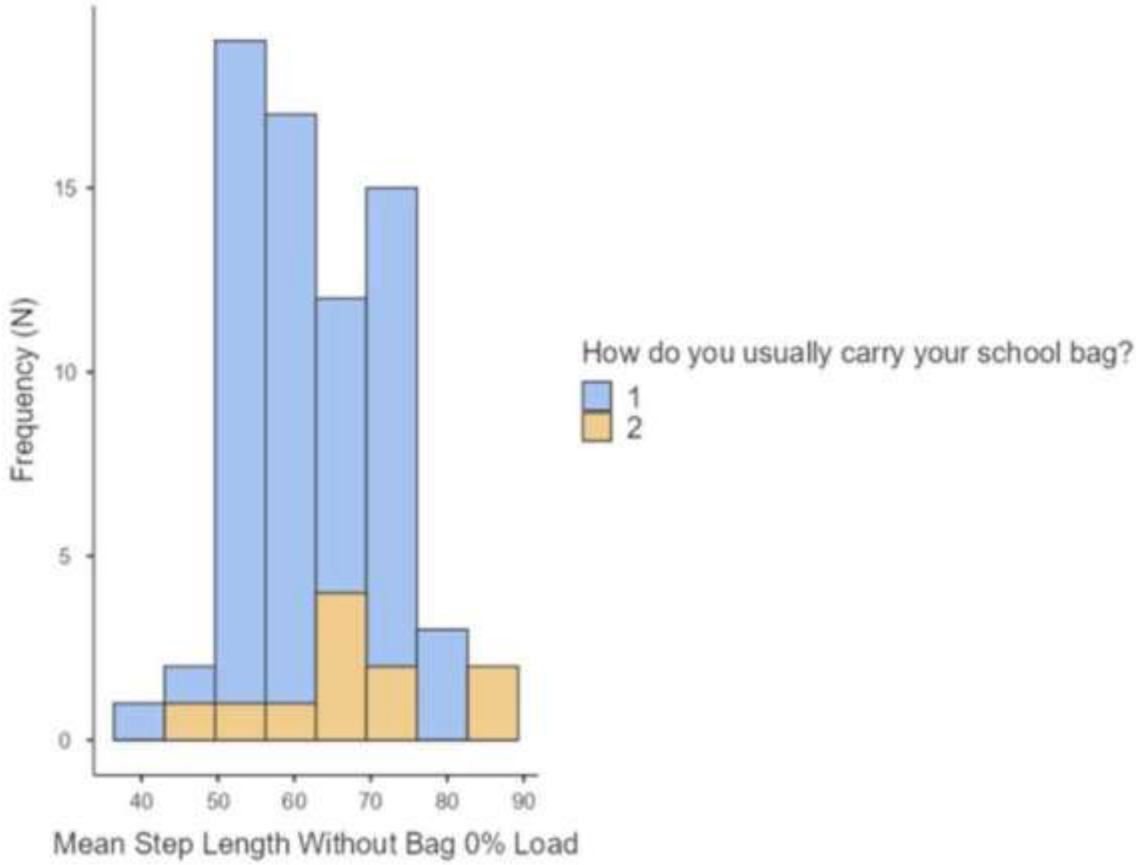
Graph no: 1.6 Histogram of Mean Step Length With a School Bag According to Whether the Child Brings a School Bag to School Every Day



Here 1 indicates Yes and 2 indicates No.

This graph shows, Approximately **97–99% of the participants** reported bringing a school bag to school every day, while only **1–3% of the participants** reported that they did not carry a school bag regularly. The mean step length while carrying a school bag was predominantly distributed between **50 cm and 75 cm**, with the highest frequency observed between **55 cm and 70 cm**

Graph no: 1.7 Histogram of Mean Step Length Without a School Bag According to the Usual Method of Carrying a School Bag



Here 1 indicates on both shoulders and 2 indicates on one shoulder.

This graph shows, Approximately **85–90% of participants** used both shoulders to carry their school bag, while **10–15% of participants** preferred carrying the bag on one shoulder. The mean step length without a school bag was primarily distributed between **50 cm and 75 cm**, with the highest frequency observed within the **55–65 cm** range

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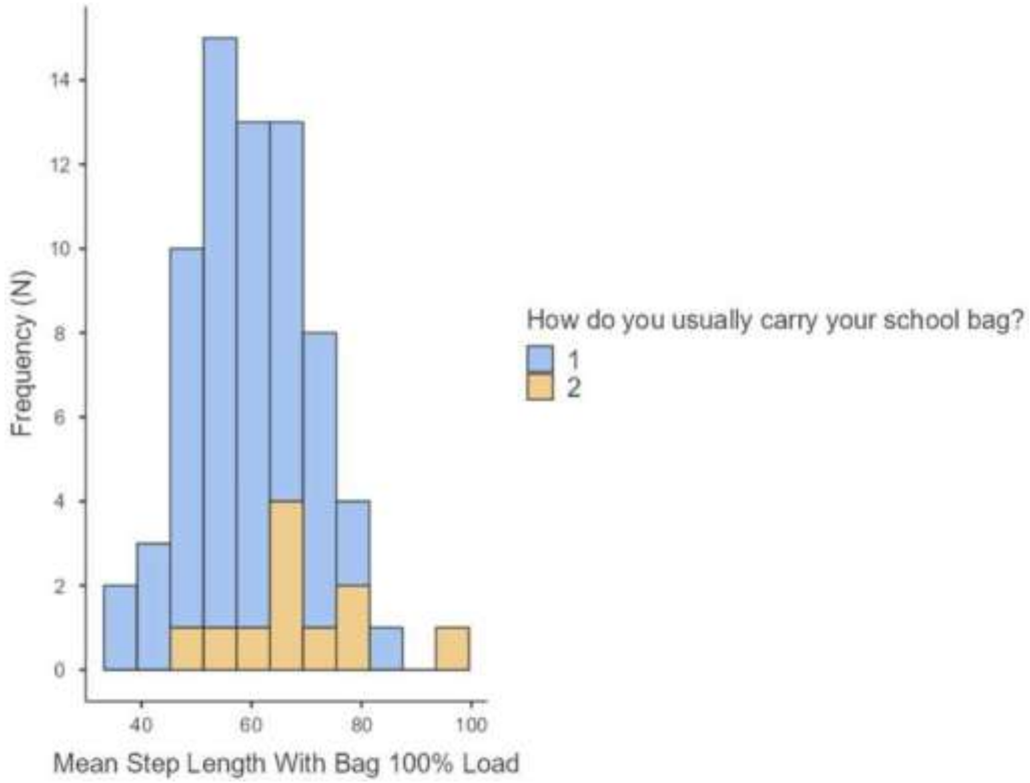
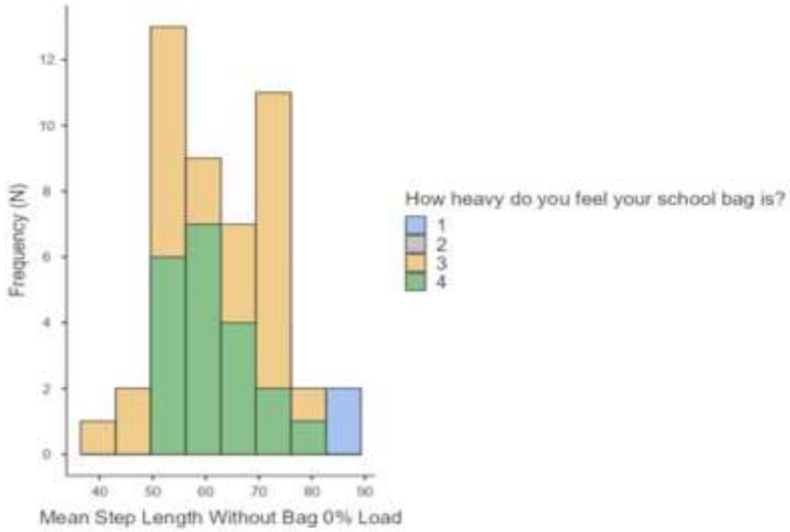
Graph no: 1.8 Histogram of Mean Step Length With a School Bag According to the Usual Method of Carrying a School Bag



. Here 1 indicates on both shoulders and 2 indicates on one shoulder.

This graph shows, Approximately **85–90%** of participants carried the bag using **both shoulders**, while **10–15%** used **one shoulder**. Mean step length was mainly distributed between **50 and 70 cm**, with the highest frequency occurring within the **55–65 cm** range. Most observations were associated with the two-shoulder carrying method, indicating it was the predominant carrying style among participants.

Graph no: 1.9 Histogram of Mean Step Length Without a School Bag According to the Perceived Heaviness of the School Bag



Here I indicates very light, 2 indicates light, 3 indicates heavy and 4 indicates very heavy.

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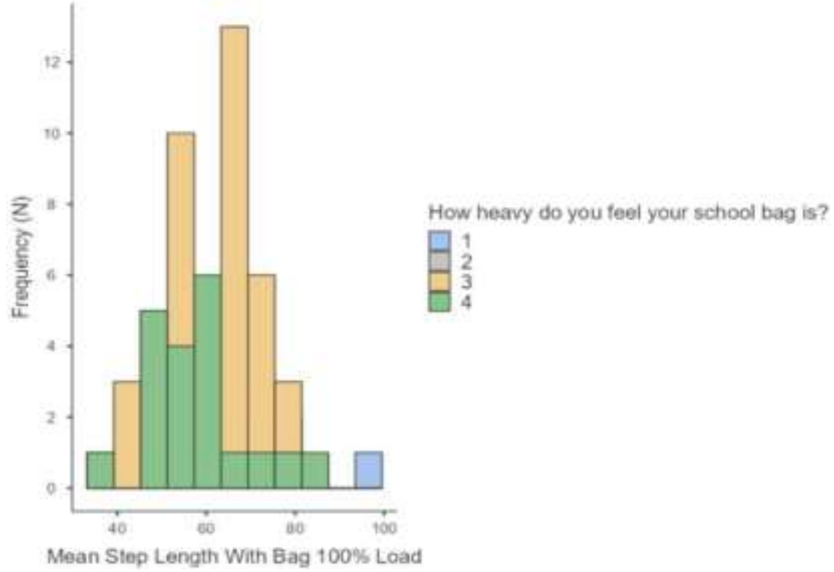
This graph shows, Most participants rated their school bags as **moderately heavy (**rating 2), followed by slightly heavy (rating 3) and heavy (rating 4), while very few participants selected rating 1. The mean step length was primarily distributed between 50 cm and 75 cm, with the highest frequency observed within the 55–65 cm range.

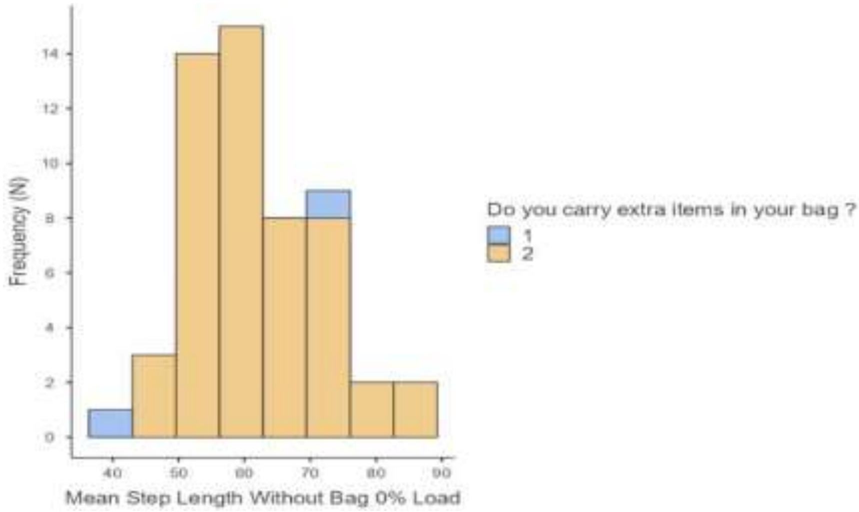
Graph no: 1.10 Histogram of Mean Step Length With a School Bag According to the Perceived Heaviness of the School Bag



Here I indicates very light, 2 indicates light, 3 indicates heavy and 4 indicates very heavy.

This graph shows, Most participants rated their school bags as **moderately heavy (rating 2)**, followed by **heavy (rating 4)** and **slightly heavy (rating 3)**, while very few participants selected **rating 1**. The mean step length was primarily distributed between **50 cm and 75 cm**, with the highest frequency observed within the **55–65 cm** range. A small number of observations occurred at the lower (<45 cm) and higher (>80 cm) ends of the distribution, indicating limited variability outside the central range

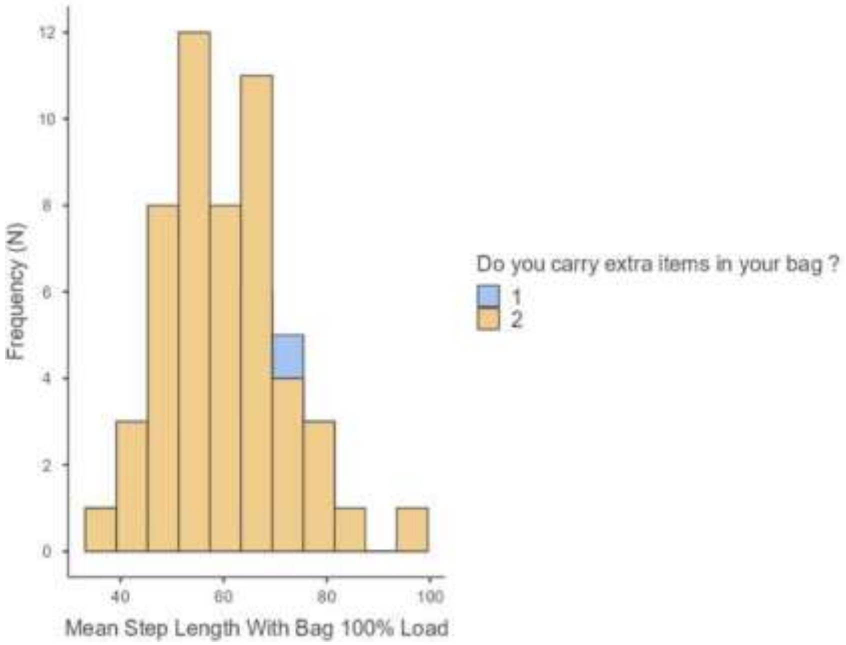
Graph no: 1.11 Histogram of Mean Step Length Without a School Bag According to Whether Extra Items Are Carried in the School Bag



Here 1 indicates Yes and 2 indicates No.

This graph shows, The majority of participants had a **mean step length between 55 and 70 units**, with the highest concentration occurring around **60–65 units**. Approximately **70–80% of observations** appear to fall within this range, suggesting that normal walking without an external load results in relatively consistent step lengths among participants. Participants in category **2** (light yellow bars) constitute the vast majority of the sample, representing an estimated **90–95% of observations**,

Graph no: 1.12 Histogram of Mean Step Length With a School Bag According to Whether Extra Items Are Carried in the School Bag



Here, 1 indicates Yes and 2 indicates No.

This graph shows, most participants recorded step lengths between 50 and 70 units, accounting for approximately 75–85% of all observations, with the highest frequencies occurring around 55–65 units. Participants in category 2 (light yellow bars) represent the overwhelming majority of the sample (approximately 90–95%), while category 1 (blue bars) contributes only a small proportion (approximately 5–10%). Compared with the no-load condition, the distribution under the 100% load condition appears slightly more dispersed, with a few observations extending to higher values (up to about 100 units) and fewer observations at the extreme lower end. The distribution exhibits a slight positive skew, as approximately 10–15% of participants have step lengths above 75 units, while less than 5% fall below 45 units.

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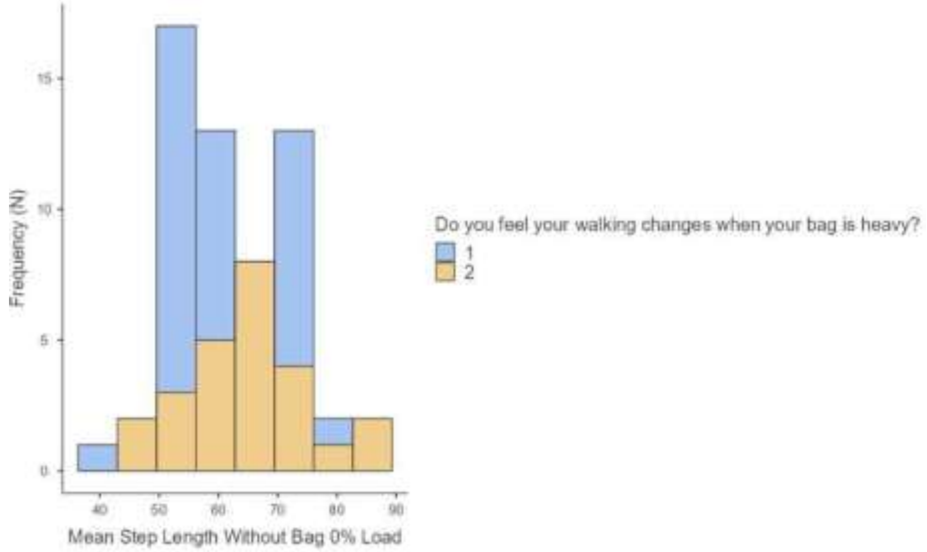
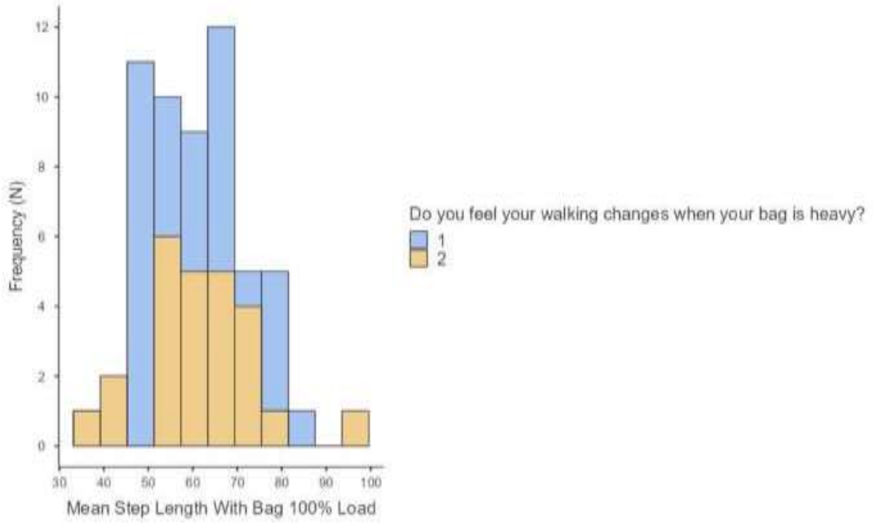
Graph no: 1.13 Histogram of Mean Step Length Without a School Bag According to Whether the Child Feels That Walking Changes When the School Bag Is Heavy



Here 1 indicates Yes and 2 indicates No.

This graph shows, that most observations are concentrated between 55 and 75 units, representing approximately 75–85% of the sample. Participants who reported that their walking changes when their bag is heavy (category 1, blue bars) account for the majority of observations, estimated at 65–75%, whereas those who reported no noticeable change (category 2, yellow bars) comprise approximately 25–35% of the sample. The highest frequencies occur within the 55–70 unit range, suggesting that normal walking without a load is characterized by relatively consistent step lengths across participants. The distribution shows a slight positive skew, with only a small proportion of observations (5–10%) exceeding 75 units, while very few observations (less than 5%) fall below 45 units

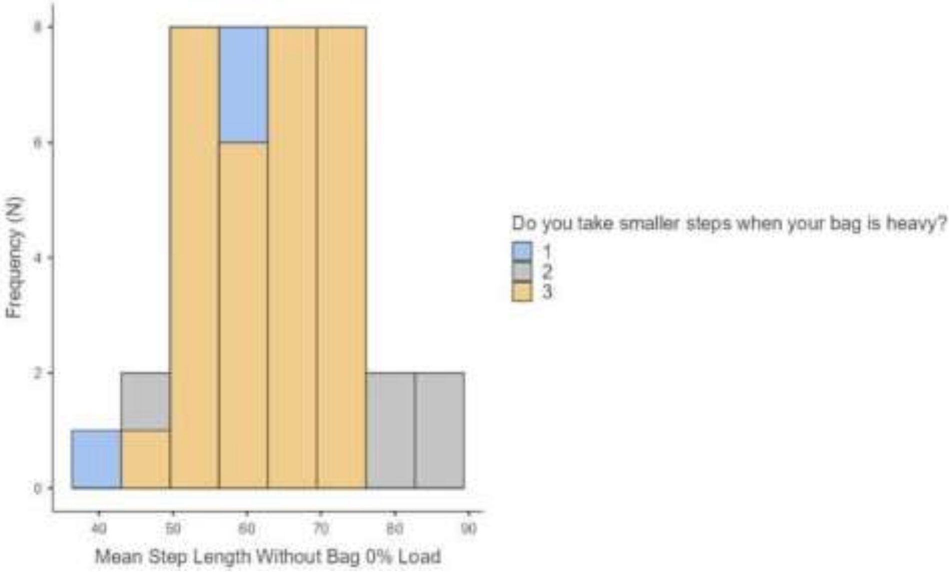
Graph no: 1.14 Histogram of Mean Step Length With a School Bag According to Whether the Child Feels That Walking Changes When the School Bag Is Heavy



Here 1 indicates Yes and 2 indicates No.

This graph shows, the majority of observations are concentrated between 50 and 75 units, accounting for approximately 80–85% of the sample. Participants who reported that their walking changes when their bag is heavy (category 1, blue bars) constitute the larger proportion of the sample, representing approximately 65–75% of observations, while those reporting no change (category 2, yellow bars) account for approximately 25–35%. The highest frequencies occur within the 55–70 unit range, indicating that most participants maintained moderate step lengths even under the fully loaded condition. The distribution displays a slight positive skew, with around 10–15% of observations exceeding 75 units, including a small number of extreme values approaching 100 units, while fewer than 5% of observations fall below 40 units

Graph no: 1.15 Histogram of Mean Step Length Without a School Bag According to Whether the Child Takes Smaller Steps When the School Bag Is Heavy



Here 1 indicates Yes, 2 indicates No and 3 indicates Sometimes.

This graph shows, the most observations are concentrated between 50 and 75 units, accounting for approximately 80–90% of the sample. Participants in category 3 (yellow bars) represent the largest proportion of observations, estimated at 70–80%, while categories 1 (blue bars) and 2 (gray bars) together account for approximately 20–30% of the sample. The highest frequencies occur within the 55–70 unit range, suggesting that participants generally exhibit moderate and relatively consistent step lengths under no-load conditions. The distribution is approximately normal with a slight positive skew, as a small proportion of observations (5–10%) extend beyond 75 units, while very few observations (less than 5%) fall below 45 units

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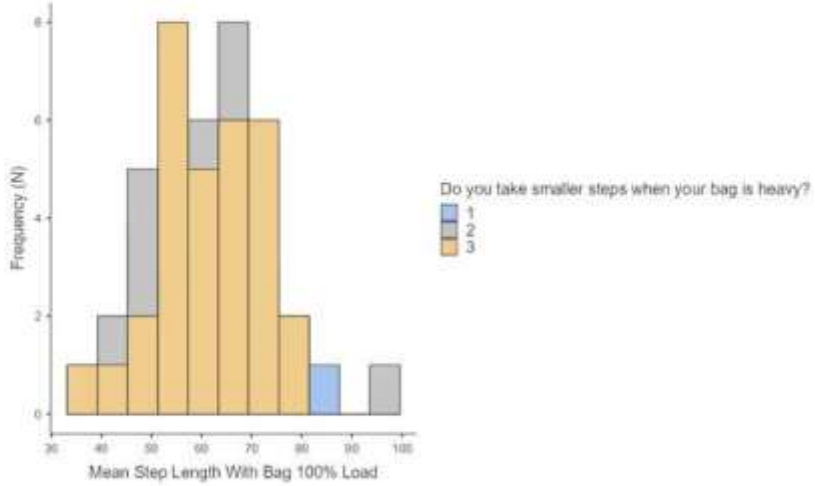
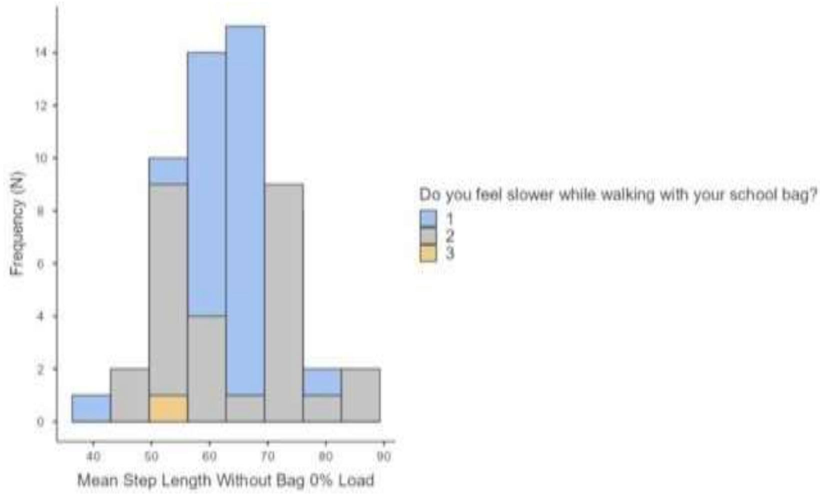
Graph no: 1.16 Histogram of Mean Step Length With a School Bag According to Whether the Child Takes Smaller Steps When the School Bag Is Heavy



Here, 1 indicates Yes, 2 indicates No and 3 indicates Sometimes.

This graph shows, the most observations are concentrated between **50 and 75 units**, representing approximately **80–85% of the sample**. Participants in category **3** (yellow bars) constitute the majority of observations, accounting for an estimated **65–75%** of the sample, while category **2** (gray bars) represents approximately **20–30%**, and category **1** (blue bars) contributes only a small proportion (**less than 10%**). The highest frequencies occur within the **55–70 unit range**, indicating that most participants maintained moderate step lengths even while carrying a fully loaded bag. The distribution exhibits a **slight positive skew**, with approximately **10–15%** of observations exceeding **75 units**, including a few extreme values approaching **90–100 units**, whereas fewer than **5%** of observations fall below **40 units**

Graph no: 1.17 Histogram of Mean Step Length Without a School Bag According to Whether the Child Feels Slower While Walking With the School Bag



Here 1 indicates Yes and 2 indicates No.

The graph shows, the most observations are concentrated between 55 and 75 units, accounting for approximately 80–90% of the sample. Participants in category 1 (blue bars) represent the largest proportion of observations, estimated at 60–70%, while category 2 (gray bars) accounts for approximately 25–35%, and category 3 (yellow bars) contributes only a very small proportion (less

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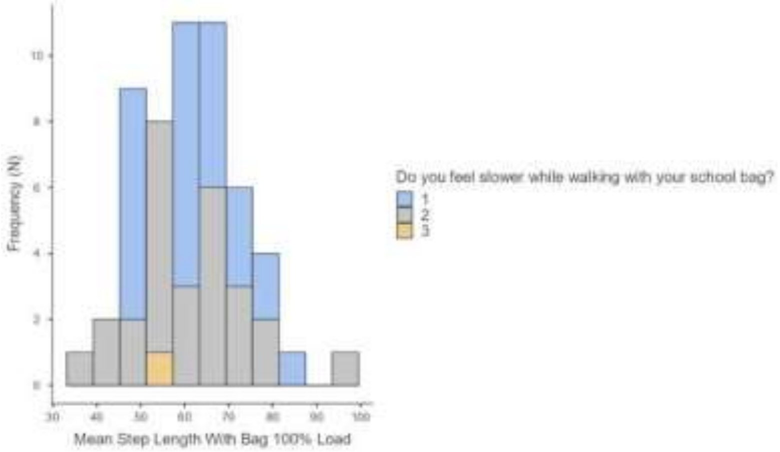
than 5%). The highest frequencies occur within the 60–70 unit range, suggesting that participants generally exhibit consistent step lengths under unloaded conditions. The distribution is approximately normal with a slight positive skew, as a small number of observations (5–10%) extend beyond 75 units, while very few observations (less than 5%) fall below 45 units

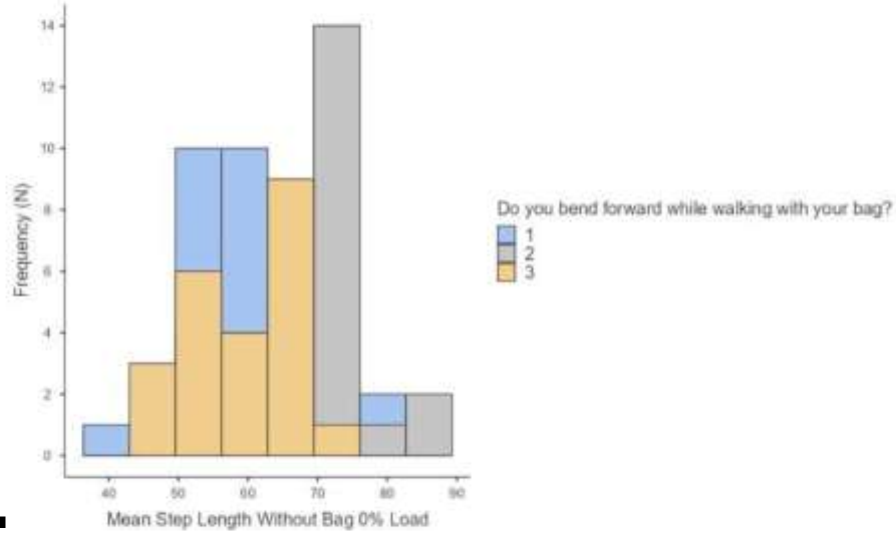
Graph no: 1.18 Histogram of Mean Step Length With a School Bag According to Whether the Child Feels Slower While Walking With the School Bag



Here 1 indicates Yes and 2 indicates No.

The graph shows, the majority of observations are concentrated between 50 and 75 units, representing approximately 80–90% of the sample. Participants in category 1 (blue bars) account for the largest proportion of observations, estimated at 60–70%, while category 2 (gray bars) comprises approximately 25–35%, and category 3 (yellow bars) contributes only a very small proportion (less than 5%). The highest frequencies occur within the 55–70 unit range, indicating that most participants maintained moderate step lengths even while carrying a fully loaded school bag. The distribution exhibits a slight positive skew, with approximately 10–15% of observations exceeding 75 units, including a few values approaching 90–100 units, whereas fewer than 5% of observations fall below 40 units

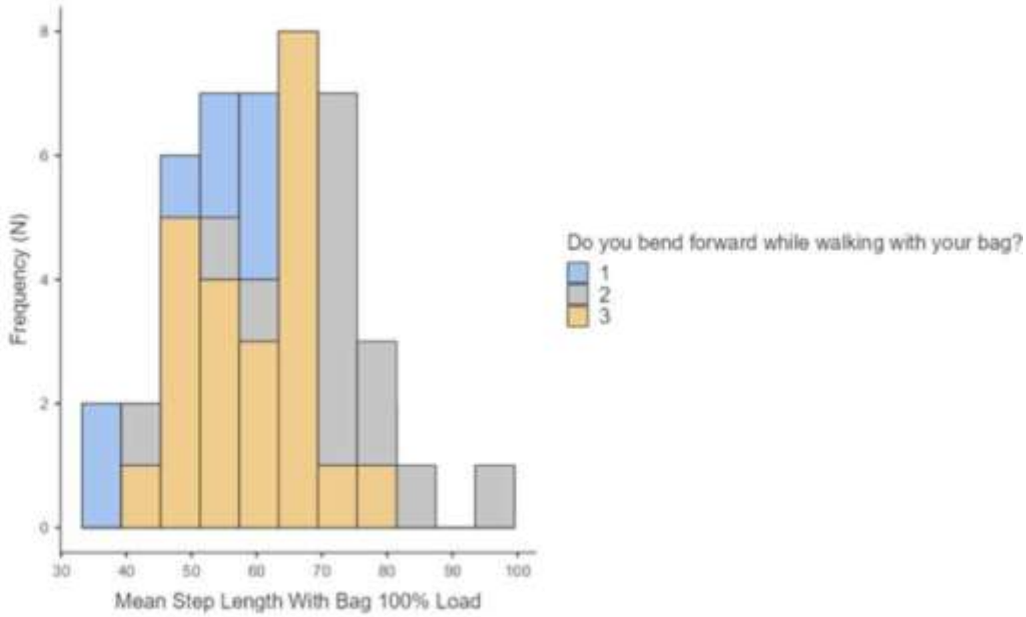
Graph no: 1.19 Histogram of Mean Step Length Without a School Bag According to Whether the Child Bends Forward While Walking With the School Bag



Here, 1 indicates Yes, 2 indicates No and 3 indicates Sometimes.

This graph shows, most observations are concentrated between 55 and 75 units, accounting for approximately 80–90% of the sample. Participants in category 2 (gray bars) represent the largest proportion of observations, estimated at 40–50%, while categories 1 (blue bars) and 3 (yellow bars) contribute approximately 25–35% each. The highest frequencies occur within the 60–75 unit range, suggesting that participants generally maintain moderate and relatively consistent step lengths under unloaded conditions. The distribution is approximately normal with a slight positive skew, as a small proportion of observations (5–10%) extend beyond 75 units, while very few observations (less than 5%) fall below 45 units.

Graph no: 1.20 Histogram of Mean Step Length With a School Bag According to Whether the Child Bends Forward While Walking With the School Bag



Here, 1 indicates Yes, 2 indicates No and 3 indicates Sometimes.

This graph shows, the most observations are concentrated between **50 and 75 units**, accounting for approximately **80–85% of the sample**. Participants in category **2** (gray bars) appear to represent the largest proportion of observations, estimated at **40–50%**, while categories **1** (blue bars) and **3** (yellow bars) each contribute approximately **25–35%** of the sample. The highest frequencies occur within the **55–70 unit range**, indicating that most participants maintained moderate step lengths even while carrying a fully loaded bag. The distribution demonstrates a **slight positive skew**, with approximately **10–15%** of observations exceeding **75 units**, including a few extreme values approaching **90–100 units**, whereas fewer than **5%** of observations fall below **40 units**.

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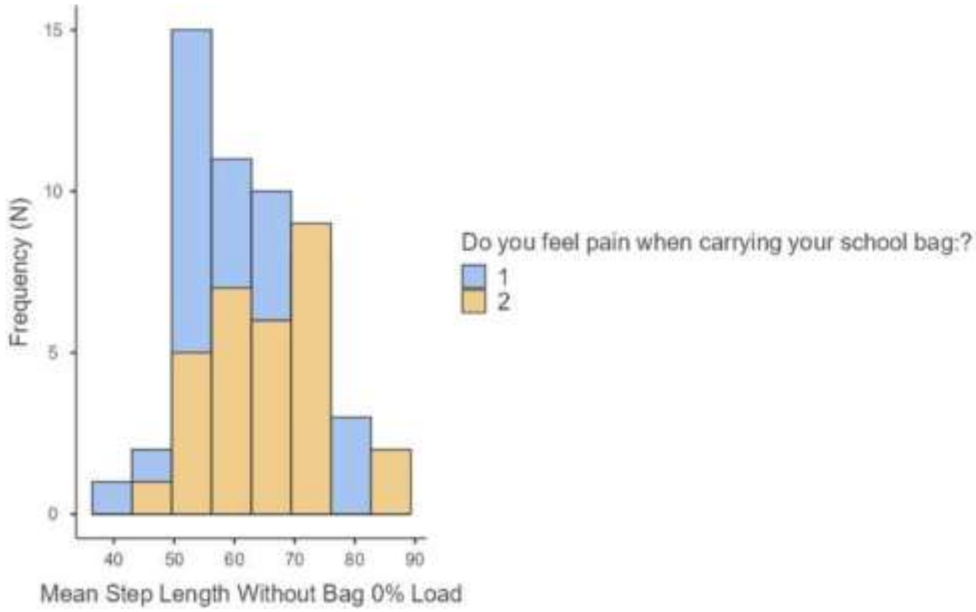
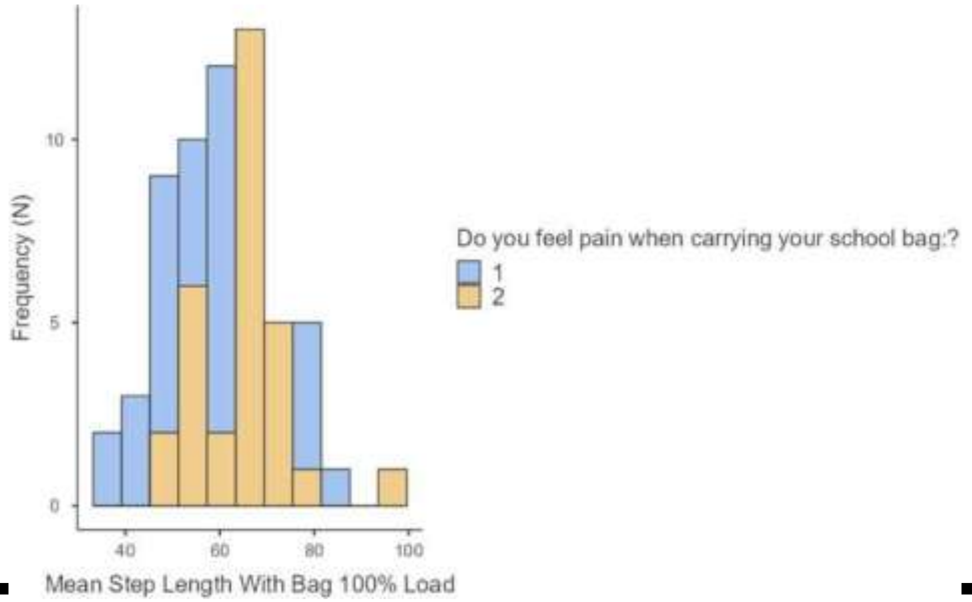
Graph no: 1.21Histogram of Mean Step Length Without a School Bag According to Whether the Child Experiences Pain While Carrying the School Bag



Here 1 indicates Yes and 2 indicates No.

The graph shows, the most observations are concentrated between **50 and 75 units**, accounting for approximately **80–90% of the sample**. Participants in category **1** (blue bars) represent a slightly larger proportion of observations, estimated at **55–65%**, while category **2** (yellow bars) accounts for approximately **35–45%** of the sample. The highest frequencies occur within the **55–70 unit range**, suggesting that participants generally exhibit moderate and relatively consistent step lengths under unloaded conditions. The distribution is approximately normal with a slight positive skew, as around **5–10%** of observations exceed **75 units**, while very few observations (**less than 5%**) fall below **45 units**

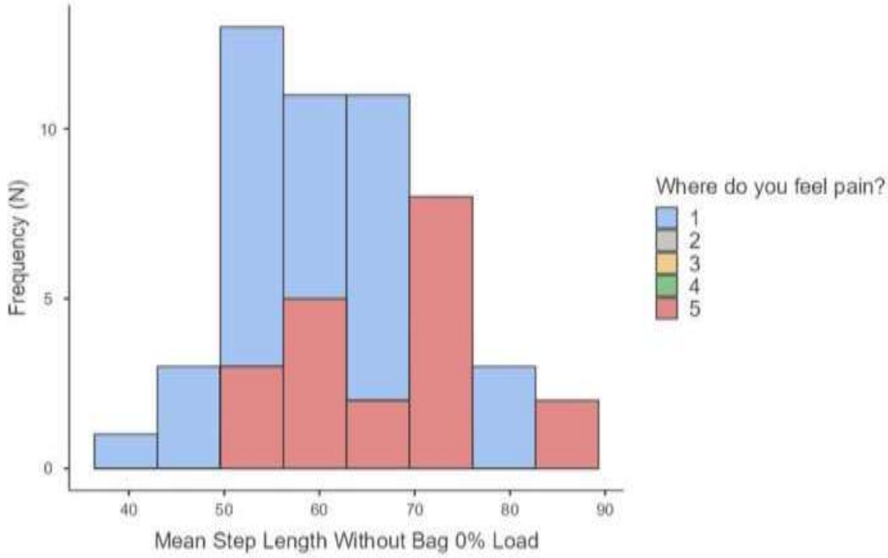
Graph no: 1.22 Histogram of Mean Step Length With a School Bag According to Whether the Child Experiences Pain While Carrying the School Bag



Here 1 indicates Yes and 2 indicates No.

The graph shows, that most observations are concentrated between 50 and 75 units, representing approximately 80–90% of the sample. Participants in category 1 (blue bars) constitute the larger proportion of observations, estimated at 60–70%, while category 2 (yellow bars) accounts for approximately 30–40% of the sample. The highest frequencies occur within the 55–70 unit range, indicating that most participants maintained moderate step lengths while carrying a fully loaded school bag. The distribution exhibits a slight positive skew, with approximately 10–15% of observations exceeding 75 units, including a few extreme values approaching 90–100 units, whereas fewer than 5% of observations fall below 40 units

Graph no: 1.23 Histogram of Mean Step Length Without a School Bag According to the Location Where Pain Is Experienced



Here 1 indicates Shoulder, 2 indicates Neck, 3 indicates Back, 4 indicates Legs and 5 indicates No Pain.

The graph shows, most observations are concentrated between 50 and 75 units, accounting for approximately 80–90% of the sample. Participants in category 1 (blue bars) and category 5 (red bars) appear to represent the largest proportions of observations, together accounting for approximately 70–80% of the sample, while categories 2, 3, and 4 contribute only a small number of observations. The highest frequencies occur within the 55–70 unit range, suggesting that participants generally exhibit moderate and relatively consistent step lengths under unloaded conditions regardless of the timing of pain experienced. The distribution is approximately normal with a slight positive skew, as around 5–10% of observations exceed 75 units, while very few observations (less than 5%) fall below 45 units.

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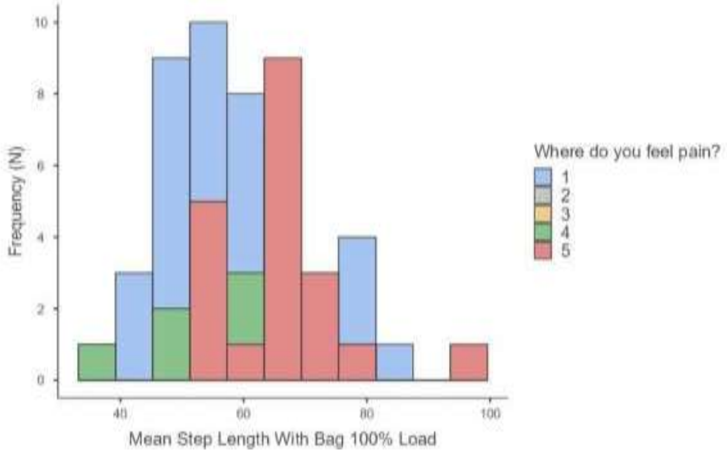
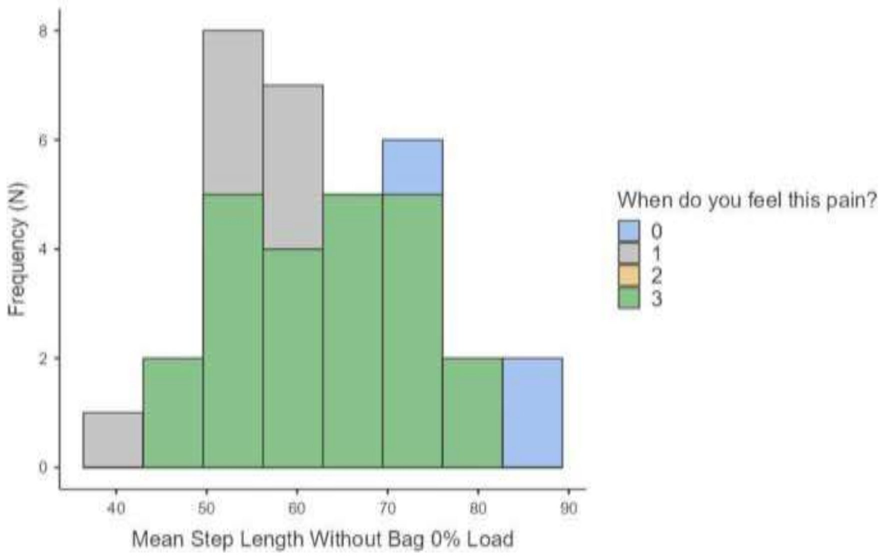
Graph no: 1.24 Histogram of Mean Step Length With a School Bag According to the Location Where Pain Is Experienced



Here 1 indicates Shoulder, 2 indicates Neck, 3 indicates Back, 4 indicates Legs and 5 indicates No Pain.

This graph shows, most observations are concentrated between 50 and 75 units, accounting for approximately 80–90% of the sample. Participants in category 1 (blue bars) and category 5 (red bars) appear to represent the largest proportions of observations, together contributing approximately 75–85% of the sample, while categories 3 (green bars) and the remaining categories account for relatively few observations. The highest frequencies occur within the 55–70 unit range, indicating that most participants maintained moderate step lengths despite carrying a fully loaded school bag. The distribution exhibits a slight positive skew, with approximately 10–15% of observations extending beyond 75 units, including a few extreme values approaching 90–100 units, whereas fewer than 5% of observations fall below 40 units

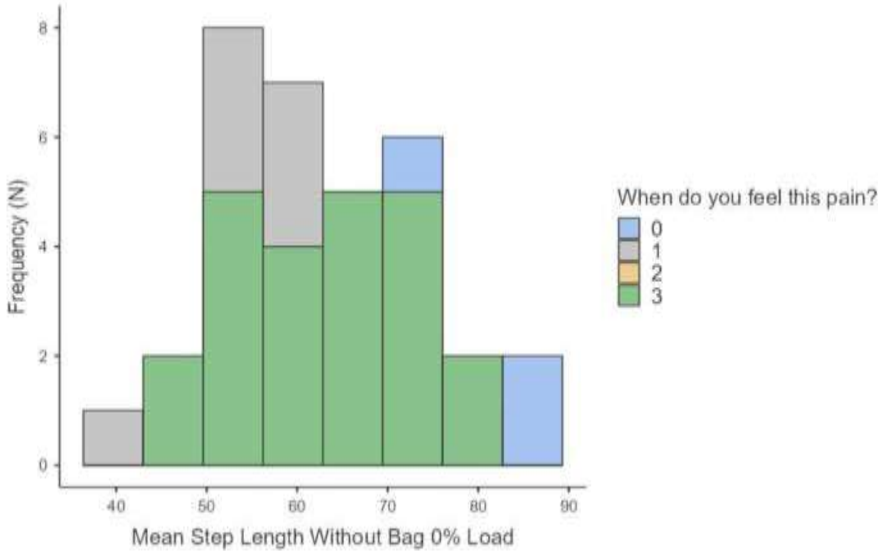
Graph no: 1.25 Histogram of Mean Step Length Without a School Bag According to When Pain Is Experienced



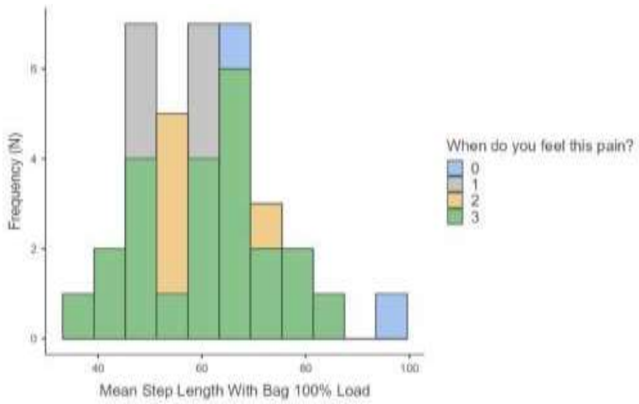
Here, 0 indicates No Pain, 1 indicates while walking, 2 indicates after reaching school and 3 indicates after a long time carrying the bag.

This graph shows, observations are concentrated between 50 and 75 units, accounting for approximately 80–90% of the sample. Participants in categories 1 (gray bars) and 3 (green bars) represent the largest proportions of observations, together contributing approximately 80–90% of the sample, while categories 0 (blue bars) and 2 (yellow bars) account for only a small number of observations. The highest frequencies occur within the 55–70 unit range, suggesting that participants generally exhibit moderate and relatively consistent step lengths under unloaded conditions regardless of when pain is experienced. The distribution is approximately normal with a slight positive skew, as around 5–10% of observations exceed 75 units, while very few observations (less than 5%) fall below 45 units

Graph no: 1.26 Histogram of Mean Step Length With a School Bag According to When Pain Is Experienced

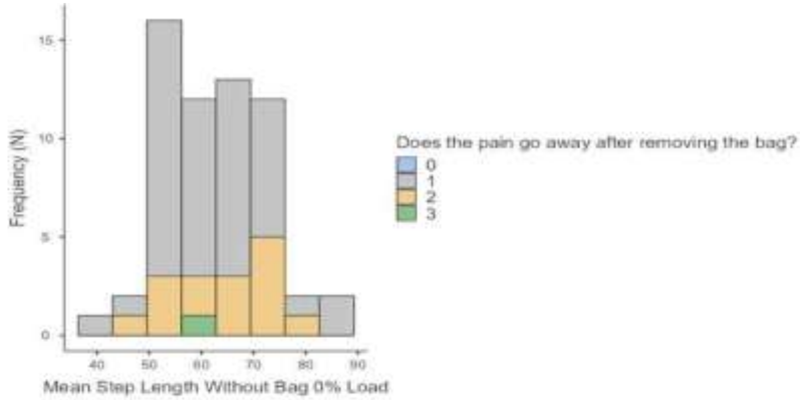


Here 0 indicates No Pain, 1 indicates while walking, 2 indicates after reaching school and 3 indicates after a long time carrying the bag.



This graph shows, most observations are concentrated between 50 and 75 units, accounting for approximately 80–90% of the sample. Participants in categories 1 (gray bars) and 3 (green bars) appear to represent the largest proportions of observations, together contributing approximately 75–85% of the sample, while categories 0 (blue bars) and 2 (yellow bars) account for a smaller proportion of observations. The highest frequencies occur within the 55–70 unit range, indicating that most participants maintained moderate step lengths while carrying a fully loaded school bag. The distribution demonstrates a slight positive skew, with approximately 10–15% of observations exceeding 75 units, including a few extreme values approaching 90–100 units, whereas fewer than 5% of observations fall below 40 units.

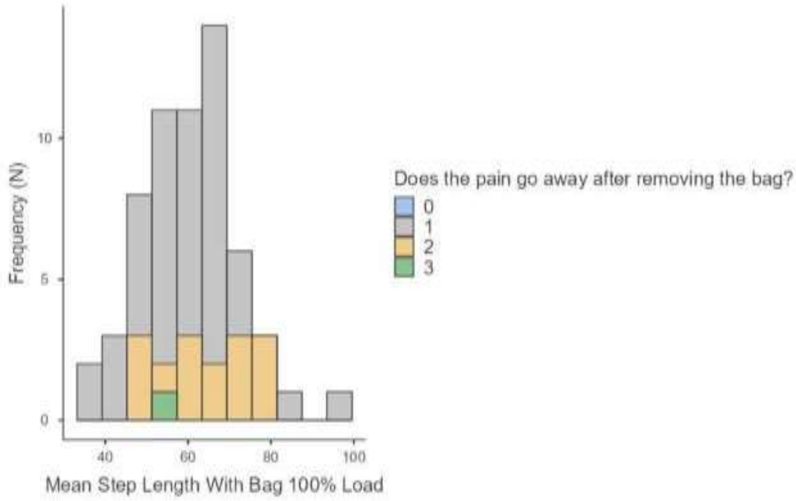
Graph no: 1.27 Histogram of Mean Step Length Without a School Bag According to Whether the Pain Subsides After Removing the School Bag



Here 0 indicates Yes, 1 indicates No, 2 indicates sometimes and 3 indicates Never.

This graph shows, that most observations are concentrated between 50 and 75 units, accounting for approximately 85–90% of the sample. Participants in category 1 (gray bars) represent the overwhelming majority of observations, estimated at 80–90%, while categories 0, 2, and 3 contribute only a small proportion of the sample. The highest frequencies occur within the 55–70 unit range, suggesting that participants generally exhibit moderate and relatively consistent step lengths under unloaded conditions. The distribution is approximately normal with a slight positive skew, as around 5–10% of observations exceed 75 units, while very few observations (less than 5%) fall below 45 units

Graph no: 1.28 Histogram of Mean Step Length With a School Bag According to Whether the Pain Subsides After Removing the School Bag



Here 0 indicates Yes, 1 indicates No, 2 indicates sometimes and 3 indicates Never.

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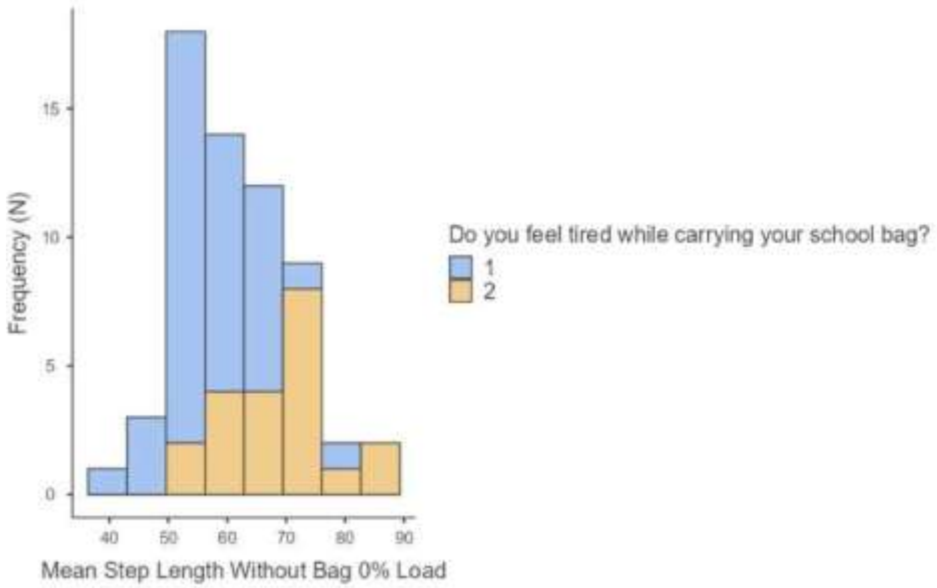
The graph shows, the observations are concentrated between 50 and 75 units, accounting for approximately 85–90% of the sample. Participants in category 1 (gray bars) represent the overwhelming majority of observations, estimated at 80–90%, while categories 0, 2, and 3 contribute only a small proportion of the sample. The highest frequencies occur within the 55–70 unit range, indicating that most participants maintained moderate step lengths while carrying a fully loaded school bag. The distribution exhibits a slight positive skew, with approximately 10–15% of observations exceeding 75 units, including a few extreme values approaching 90–100 units, whereas fewer than 5% of observations fall below 40 units

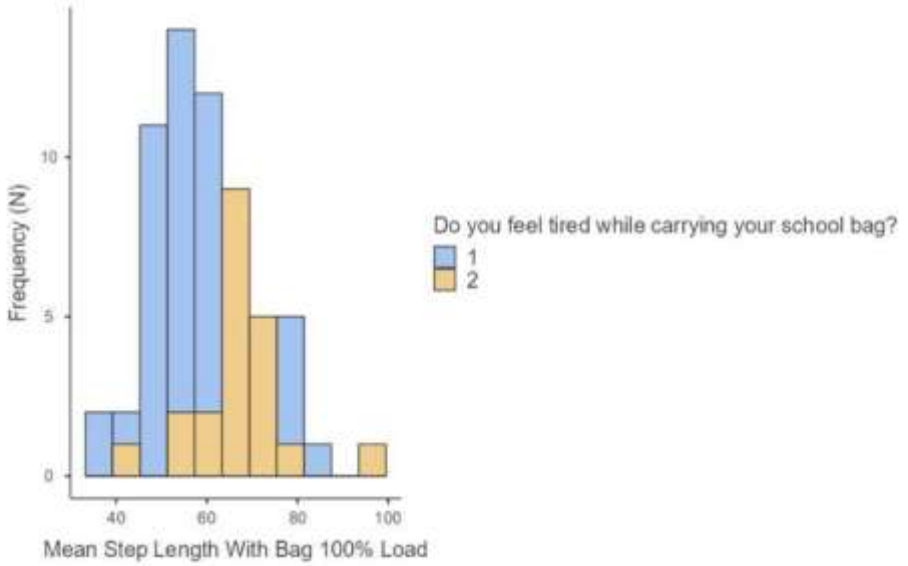
Graph no: 1.29 Histogram of Mean Step Length Without a School Bag According to Whether the Child Feels Tired While Carrying the School Bag



Here 1 indicates Yes and 2 indicates No.

This graph shows, that most observations are concentrated between 50 and 75 units, accounting for approximately 80–90% of the sample. Participants in category 1 (blue bars) represent the majority of observations, estimated at 70–80%, while category 2 (yellow bars) accounts for approximately 20–30% of the sample. The highest frequencies occur within the 55–70 unit range, suggesting that participants generally exhibit moderate and relatively consistent step lengths under unloaded conditions. The distribution is approximately normal with a slight positive skew, as around 5–10% of observations exceed 75 units, while very few observations (less than 5%) fall below 45 units.

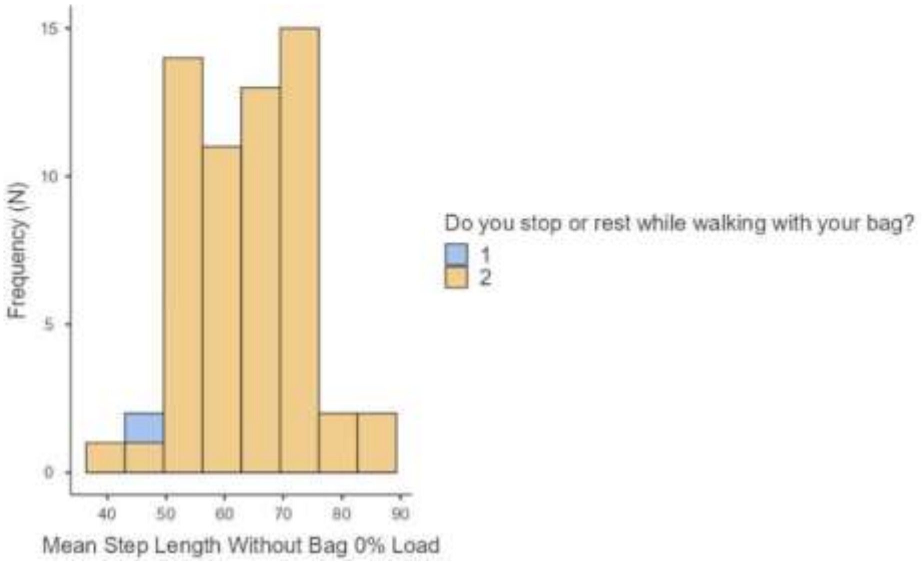
Graph no: 1.30 Histogram of Mean Step Length With a School Bag According to Whether the Child Feels Tired While Carrying the School Bag



Here 1 indicates Yes and 2 indicates No.

This graph shows, most observations are concentrated between 50 and 75 units, accounting for approximately 80–90% of the sample. Participants in category 1 (blue bars) represent the majority of observations, estimated at 70–80%, while category 2 (yellow bars) accounts for approximately 20–30% of the sample. The highest frequencies occur within the 55–70 unit range, indicating that most participants maintained moderate step lengths while carrying a fully loaded school bag. The distribution exhibits a slight positive skew, with approximately 10–15% of observations exceeding 75 units, including a few extreme values approaching 90–100 units, whereas fewer than 5% of observations fall below 40 units.

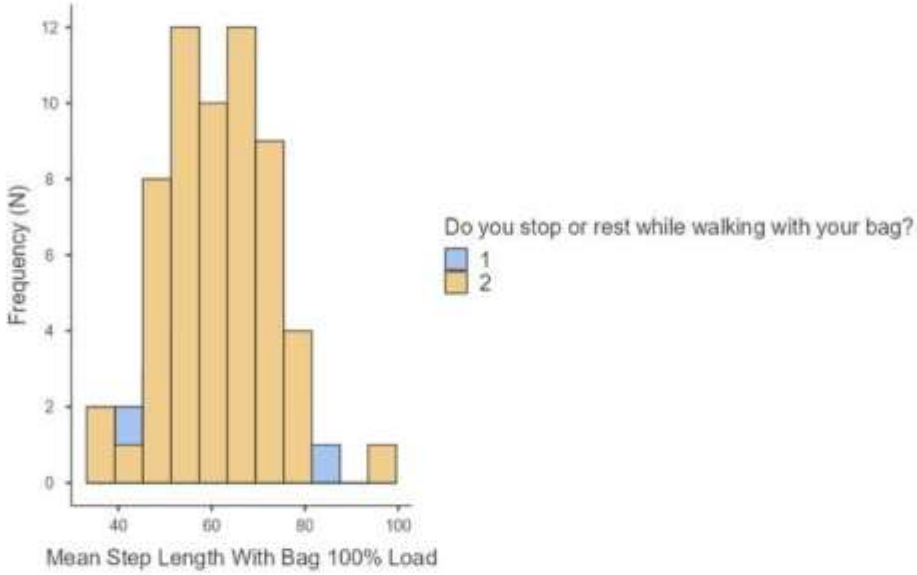
Graph no: 1.31 Histogram of Mean Step Length Without a School Bag According to Whether the Child Stops or Rests While Walking With the School Bag



Here 1 indicates Yes and 2 indicates No.

This graph shows, most observations are concentrated between 55 and 75 units, accounting for approximately 85–90% of the sample. Participants in category 2 (yellow bars) represent the overwhelming majority of observations, estimated at 90–95%, while category 1 (blue bars) contributes only a very small proportion (less than 10%). The highest frequencies occur within the 60–75 unit range, suggesting that participants generally exhibit moderate and relatively consistent step lengths under unloaded conditions. The distribution is approximately normal with a slight positive skew, as around 5–10% of observations exceed 75 units, while very few observations (less than 5%) fall below 50 units

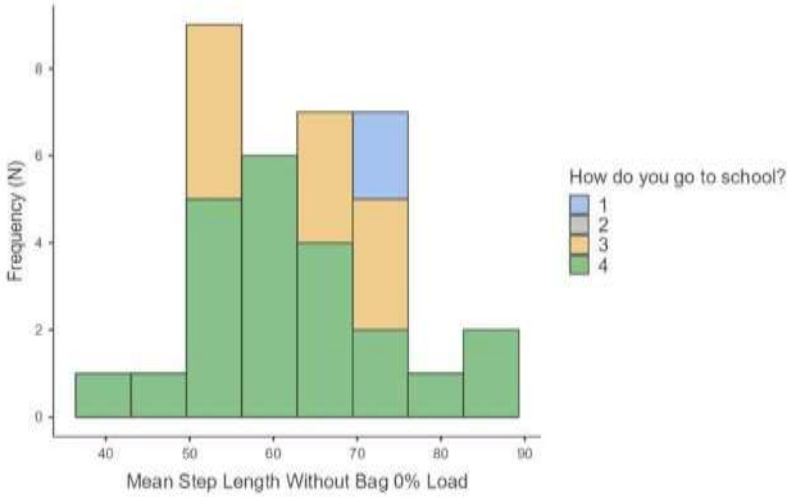
Graph no: 1.32 Histogram of Mean Step Length With a School Bag According to Whether the Child Stops or Rests While Walking With the School Bag



Here 1 indicates Yes and 2 indicates No.

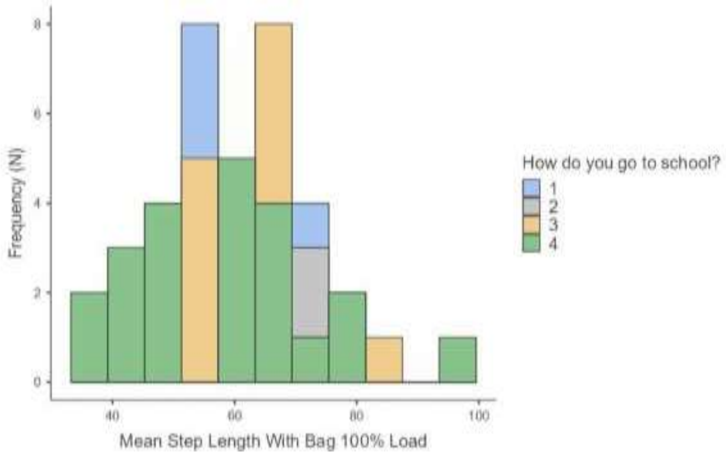
This graph shows, most observations are concentrated between 50 and 75 units, accounting for approximately 85–90% of the sample. Participants in category 2 (yellow bars) represent the overwhelming majority of observations, estimated at 90–95%, while category 1 (blue bars) contributes only a very small proportion (less than 10%). The highest frequencies occur within the 55–70 unit range, indicating that most participants maintained moderate step lengths while carrying a fully loaded school bag. The distribution exhibits a slight positive skew, with approximately 10–15% of observations exceeding 75 units, including a few values approaching 90–100 units, whereas fewer than 5% of observations fall below 40 units

Graph no: 1.33 Histogram of Mean Step Length Without a School Bag According to the Mode of Transportation Used to Travel to School



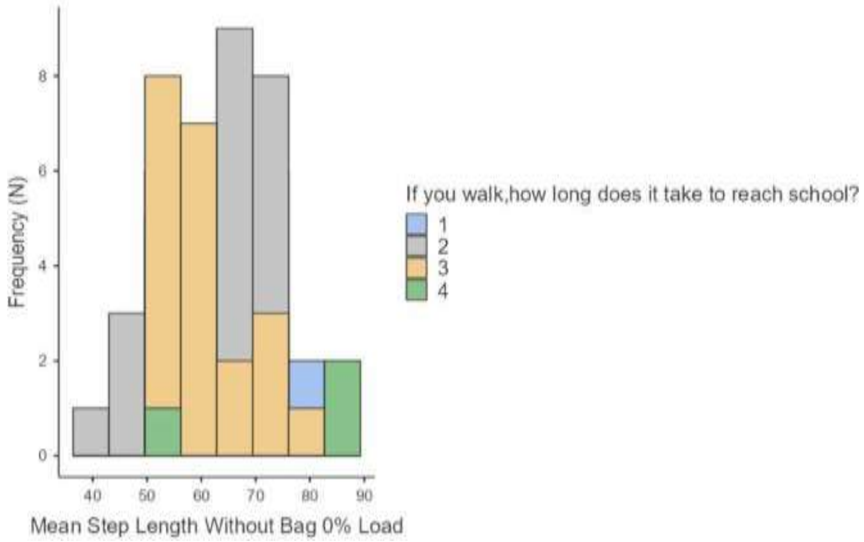
Here 1 indicates walking, 2 indicates bicycle, 3 indicates bus/auto and 4 indicates car. This graph shows, most observations are concentrated between 50 and 75 units, accounting for approximately 80–90% of the sample. Participants in categories 3 (yellow bars) and 4 (green bars) appear to represent the largest proportions of observations, together contributing approximately 75–85% of the sample, while categories 1 (blue bars) and 2 (gray bars) account for relatively few observations. The highest frequencies occur within the 55–70 unit range, suggesting that participants generally exhibit moderate and relatively consistent step lengths under unloaded conditions regardless of their mode of travel to school. The distribution is approximately normal with a slight positive skew, as around 5–10% of observations exceed 75 units, while very few observations (less than 5%) fall below 45 units

Graph no: 1.34 Histogram of Mean Step Length With a School Bag According to the Mode of Transportation Used to Travel to School



Here 1 indicates walking, 2 indicates bicycle, 3 indicates bus/auto and 4 indicates car. This graph shows, most observations are concentrated between 50 and 75 units, accounting for approximately 80–90% of the sample. Participants in categories 3 (yellow bars) and 4 (green bars) appear to represent the largest proportions of observations, together contributing approximately 70–85% of the sample, while categories 1 (blue bars) and 2 (gray bars) account for a smaller proportion of observations. The highest frequencies occur within the 55–70 unit range, indicating that most participants maintained moderate step lengths while carrying a fully loaded school bag regardless of their mode of transportation to school. The distribution demonstrates a slight positive skew, with approximately 10–15% of observations exceeding 75 units, including a few extreme values approaching 90–100 units, whereas fewer than 5% of observations fall below 40 units.

Graph no: 1.35 Histogram of Mean Step Length Without a School Bag According to the Time Taken to Reach School by Walking



Here 1 indicates less than 10 mins, 2 indicates 10-20mins, 3indicates more than 20 mins and 4 indicates more than 45 mins.

This graph shows, most observations are concentrated between 50 and 75 units, accounting for approximately 80–90% of the sample. Participants in categories 2 (gray bars) and 3 (yellow bars) appear to represent the largest proportions of observations, together contributing approximately 75–85% of the sample, while categories 1 (blue bars) and 4 (green bars) account for relatively few observations. The highest frequencies occur within the 55–70 unit range, suggesting that participants generally exhibit moderate and relatively consistent step lengths under unloaded conditions regardless of the time taken to reach school. The distribution is approximately normal with a slight positive skew, as around 5–10% of observations exceed 75 units, while very few observations (less than 5%) fall below 45 units.

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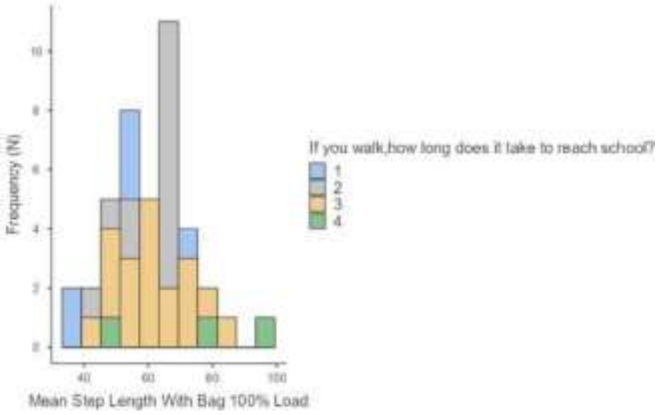
Graph no: 1.36 Histogram of Mean Step Length With a School Bag According to the Time Taken to Reach School by Walking

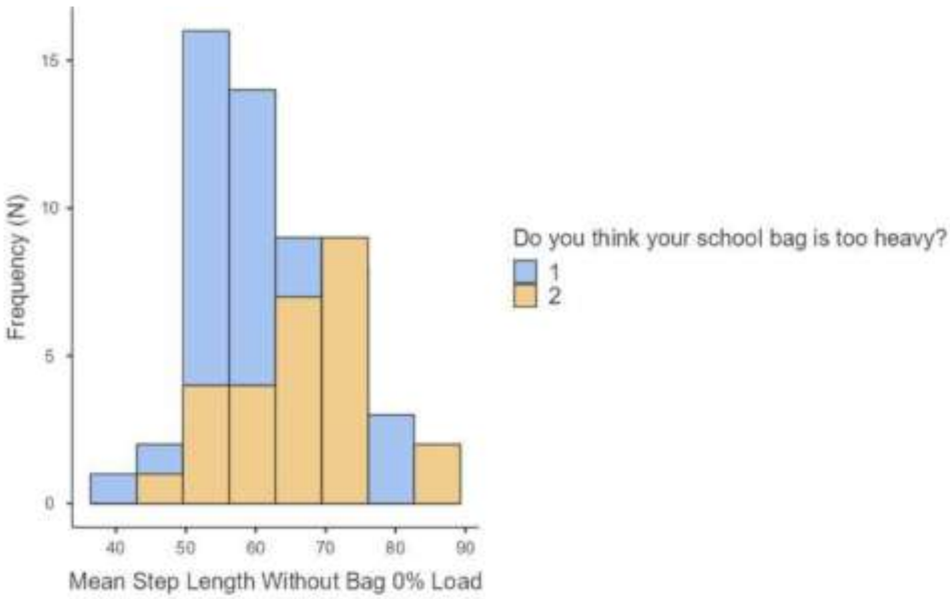


Here 1 indicates less than 10 mins, 2 indicates 10-20mins, 3indicates more than 20 mins and 4 indicates more than 45 mins.

This graph shows, most observations are concentrated between 50 and 75 units, accounting for approximately 80–90% of the sample. Participants in categories 2 (gray bars) and 3 (yellow bars) appear to represent the largest proportions of observations, together contributing approximately 75–85% of the sample, while categories 1 (blue bars) and 4 (green bars) account for relatively few observations. The highest frequencies occur within the 55–70 unit range, indicating that most participants maintained moderate step lengths while carrying a fully loaded school bag regardless of the time taken to reach school. The distribution exhibits a slight positive skew, with approximately 10–15% of observations exceeding 75 units, including a few extreme values approaching 90–100 units, whereas fewer than 5% of observations fall below 40 units.

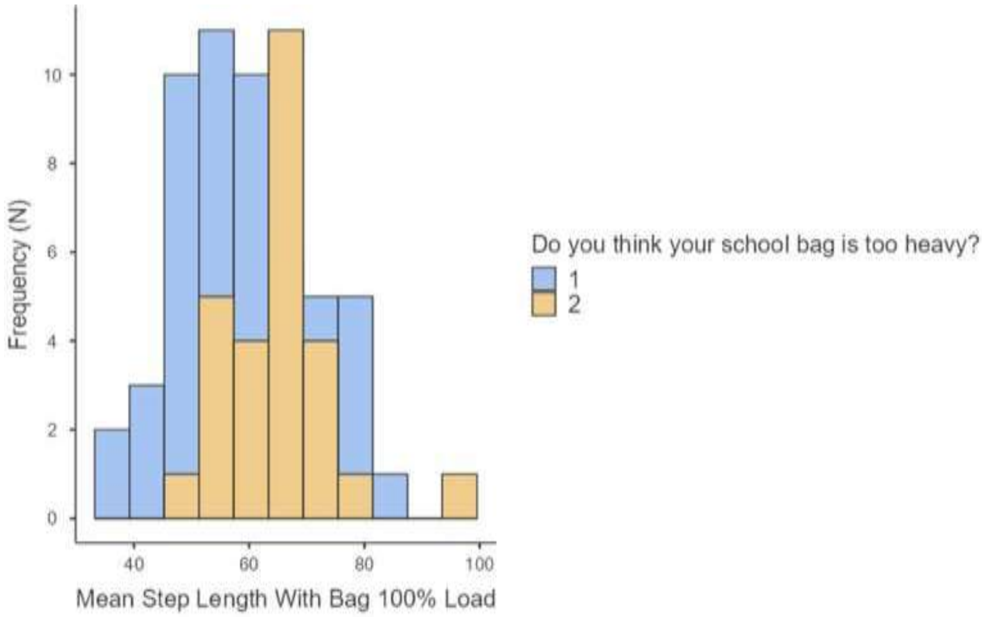
Graph no: 1.37 Histogram of Mean Step Length Without a School Bag According to Whether the Child Considers the School Bag to Be Too Heavy

Here 1 indicates Yes and 2 indicates No.



This graph shows, most observations are concentrated between 50 and 75 units, accounting for approximately 80–90% of the sample. Participants in category 1 (blue bars) represent the larger proportion of observations, estimated at 65–75%, while category 2 (yellow bars) accounts for approximately 25–35% of the sample. The highest frequencies occur within the 55–70 unit range, suggesting that participants generally exhibit moderate and relatively consistent step lengths under unloaded conditions regardless of their perception of bag weight. The distribution is approximately normal with a slight positive skew, as around 5–10% of observations exceed 75 units, while very few observations (less than 5%) fall below 45 units.

Graph no: 1.38 Histogram of Mean Step Length With a School Bag According to Whether the Child Considers the School Bag to Be Too Heavy



Here 1 indicates Yes and 2 indicates No.

This graph shows, most observations are concentrated between 50 and 75 units, accounting for approximately 80–90% of the sample. Participants in category 1 (blue bars) represent the larger proportion of observations, estimated at 65–75%, while category 2 (yellow bars) accounts for approximately 25–35% of the sample. The highest frequencies occur within the 55–70 unit range, indicating that most participants maintained moderate step lengths while carrying a fully loaded school bag. The distribution exhibits a slight positive skew, with approximately 10–15% of observations exceeding 75 units, including a few extreme values approaching 90–100 units, whereas fewer than 5% of observations fall below 40 units.

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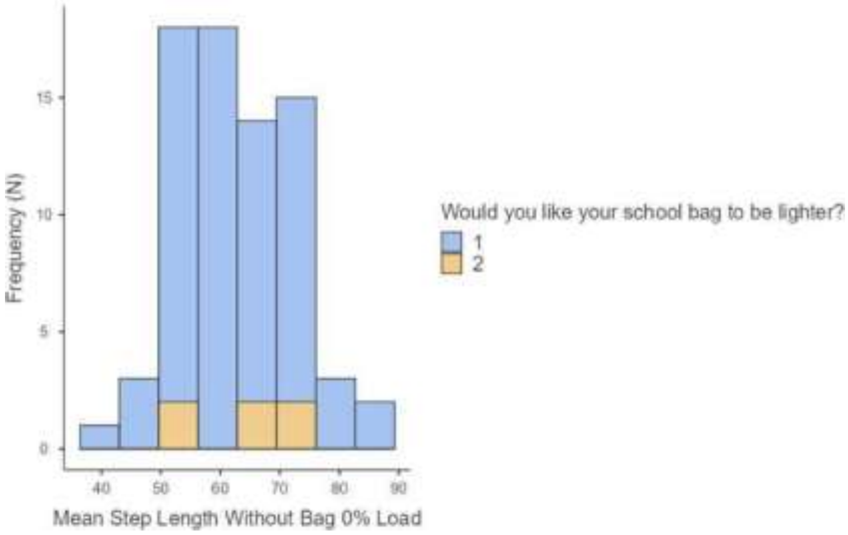
Graph no: 1.39 Histogram of Mean Step Length Without a School Bag According to Whether the Child Would Prefer a Lighter School Bag

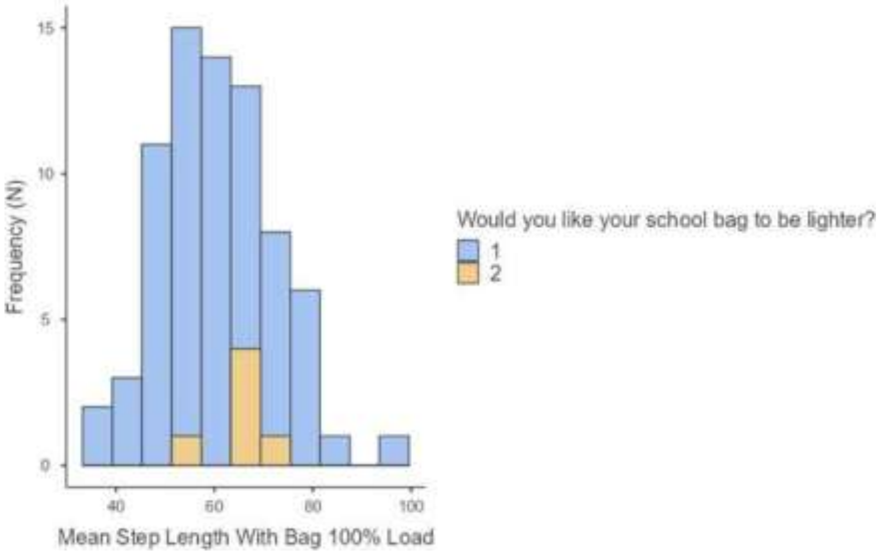
Here 1 indicates Yes and 2 indicates No.



This graph shows, most observations are concentrated between 50 and 75 units, accounting for approximately 85–90% of the sample. Participants in category 1 (blue bars) represent the overwhelming majority of observations, estimated at 90–95%, while category 2 (yellow bars) contributes only a small proportion (less than 10%) of the sample. The highest frequencies occur within the 55–70 unit range, suggesting that participants generally exhibit moderate and relatively consistent step lengths under unloaded conditions. The distribution is approximately normal with a slight positive skew, as around 5–10% of observations exceed 75 units, while very few observations (less than 5%) fall below 45 units

Graph no: 1.40 Histogram of Mean Step Length With a School Bag According to Whether the Child Would Prefer a Lighter School Bag

Here 1 indicates Yes and 2 indicates No.



This graph shows, most observations are concentrated between 50 and 75 units, accounting for

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approximately 85–90% of the sample. Participants in category 1 (blue bars) represent the overwhelming majority of observations, estimated at 90–95%, while category 2 (yellow bars) contributes only a very small proportion (less than 10%) of the sample. The highest frequencies occur within the 55–70 unit range, indicating that most participants maintained moderate step lengths while carrying a fully loaded school bag. The distribution exhibits a slight positive skew, with approximately 10–15% of observations exceeding 75 units, including a few extreme values approaching 90–100 units, whereas fewer than 5% of observations fall below 40 units.

Result

Comparison of Step Length With and Without School Bag Load

A total of 80 school-going children aged 11–15 years participated in this study investigating the effect of school bag weight on step length. Step length was measured under two walking conditions: walking without carrying a school bag (0% load condition) and walking while carrying their school bag (loaded condition). The primary objective was to determine whether carrying a school bag significantly affects step length in children.

Descriptive Statistics

The descriptive analysis showed that the mean step length in the unloaded condition was **62.5 cm** with a standard deviation of **9.54 cm**, indicating moderate variability among participants. When participants walked while carrying their school bags, the mean step length decreased slightly to **61.4 cm**, with a standard deviation of **10.95 cm**.

The reduction in mean step length observed under the loaded condition suggests that children tend to take marginally shorter steps when carrying a school bag. Additionally, the slightly higher standard deviation in the loaded condition indicates greater variability in gait patterns among participants while carrying school bags.

Table No: 5 Comparison of Step Length Under Different Conditions

Variable	**Mean (cm)**	**Standard Deviation (cm)**
Step Length without School Bag	62.5	9.54
Step Length with School Bag	61.4	10.95

The descriptive findings demonstrate a numerical reduction of approximately **1.11 cm** in mean step length when children carried their school bags compared to walking without any load.

Inferential Statistical Analysis

To determine whether the observed difference in step length was statistically significant, a paired sample t-test was performed. The paired t-test was selected because step length measurements in both conditions were obtained from the same participants, allowing direct comparison of gait performance under unloaded and loaded walking conditions.

The analysis revealed a mean difference of **1.11 cm** between the two walking conditions. The calculated t-value was **1.22** with **79 degrees of freedom (df = 79)**. The corresponding p-value obtained from the analysis was **0.224**.

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Since the obtained p-value was greater than the predetermined level of significance ($\alpha = 0.05$), the null hypothesis was retained. Therefore, the difference in step length between the unloaded and loaded walking conditions was not statistically significant.

Table No: 6 Paired Sample t-Test Comparing Step Length

Comparison	**Mean Difference (cm)**	**t-value**	**df**	**p-value**
Without Bag vs With Bag	1.11	1.22	79	0.224

Interpretation of Findings

The findings indicate that carrying a school bag produced a slight reduction in step length among children aged 11–15 years. However, the magnitude of this reduction was relatively small and did not reach statistical significance.

Although biomechanical adaptations during load carriage are commonly reported in the literature, the present study suggests that the school bag loads carried by the participants were insufficient to produce substantial alterations in step length. Children may have compensated for the additional load through postural adjustments and neuromuscular adaptations, enabling them to maintain a relatively stable gait pattern.

The observed decrease in step length may reflect an adaptive strategy aimed at enhancing stability while carrying a load. Shorter steps can reduce the displacement of the body's center of mass and improve balance during walking. Nevertheless, the extent of this adaptation in the present study was minimal and did not significantly alter overall gait performance.

Variability in Step Length

The larger standard deviation observed during loaded walking (10.95 cm) compared to unloaded walking (9.54 cm) suggests that participants responded differently to carrying school bags. Some children demonstrated noticeable reductions in step length, whereas others maintained or even increased their step length.

This variability may be attributed to differences in age, height, body mass, physical fitness, walking habits, and individual load-carrying strategies. Such factors may influence how children adapt their gait when carrying external loads.

Clinical Significance

While the statistical analysis did not demonstrate a significant effect of school bag weight on step length, the slight reduction observed may still have practical implications when considered over prolonged periods of daily school bag use. Repeated exposure to heavy school bags may contribute to subtle biomechanical changes that are not immediately evident through a single gait parameter assessment.

However, based on the findings of the present study, school bag carriage did not significantly impair step length among children aged 11–15 years. This suggests that, under the loading conditions examined, children were able to maintain a relatively normal walking pattern despite carrying their

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school bags.

Discussion

The present study was conducted to determine the effect of school bag weight on step length in children aged 11–15 years. The findings demonstrated that step length decreased when children carried school bags compared to walking without a load. Although the reduction may vary depending on the weight of the bag and individual characteristics of the child, the results suggest that carrying a school bag alters normal gait mechanics and may affect walking efficiency. Conclusion was The present study found a slight reduction in step length when children carried school bags compared to walking without a load. However, this reduction was not statistically significant, suggesting that the school bag loads carried by the participants did not substantially affect step length in children aged 11–15 years.

The decrease in step length observed in this study is consistent with previous research showing that external loads carried in backpacks can modify spatiotemporal gait parameters. Tomal et al. reported that backpack loads exceeding 10% of body weight resulted in a significant reduction in step length and changes in gait patterns among school children. The authors suggested that children shorten their steps as a compensatory strategy to maintain balance and reduce instability caused by the posterior displacement of the center of mass.[6] Conclusion was Although Tomal et al. reported significant reductions in step length with increasing backpack loads, the findings of the present study did not demonstrate a statistically significant change. This difference may be due to variations in backpack weight, participant characteristics, or study methodology.

Similarly, Mueller et al. found that increasing backpack weight led to reduced stride length and gait velocity in children. According to the authors, heavier loads force children to adopt a more cautious walking pattern characterized by shorter steps and reduced trunk movement, helping them maintain postural stability during locomotion.[16] Conclusion was While Mueller et al. observed reduced stride length and gait velocity with heavier backpack loads, the present study showed only a minimal, non-significant decrease in step length. These findings suggest that the school bag loads in the current study may not have been sufficient to cause marked gait alterations.

The findings of the present study are also supported by Ahmad and Barbosa, who investigated the effects of backpack carriage on gait kinematics in schoolchildren. They reported that carrying school bags altered several gait parameters and caused children to walk more slowly. Although stride length changes were not significant in all loading conditions, the study confirmed that backpack weight influences normal gait biomechanics and increases mechanical stress during walking.[17] conclusion was The findings of Ahmad and Barbosa support the concept that backpack carriage influences gait biomechanics. However, similar to some of their loading conditions, the present study found that changes in step length were not statistically significant, indicating a limited effect of school bag weight on this gait parameter.

Furthermore, Grobler et al. observed that excessive schoolbag loads produced acute alterations in gait and posture. The researchers noted that heavier backpacks increase the demand on the musculoskeletal system and require compensatory adaptations during walking. These adaptations include changes in trunk position, gait speed, and step characteristics, which may contribute to fatigue and discomfort if maintained

over prolonged periods.[2] Conclusion was Grobler et al. reported notable gait and postural adaptations associated with excessive schoolbag loads. In contrast, the present study identified only a slight reduction in step length, suggesting that the loads carried by participants may not have been heavy enough to produce significant biomechanical changes.
The reduction in step length observed in the present study can be explained biomechanically. When a child carries a heavy school bag, the body's center of gravity shifts posteriorly. To counteract this shift and maintain balance, the child leans forward and adopts shorter steps. This strategy increases stability by keeping the center of mass within the base of support during walking. However, prolonged use of heavy school bags may increase energy expenditure and place additional stress on the lower limbs and spine.[18] Conclusion was Biomechanically, children may adopt shorter steps as a compensatory mechanism to maintain stability while carrying a load. Although this trend was observed in the present study, the magnitude of change was small and did not reach statistical significance
Studies focusing on adolescents aged 11–15 years have also highlighted that this age group is particularly vulnerable because of ongoing musculoskeletal growth and development. Excessive backpack loads may influence posture, foot pressure distribution, balance, and gait parameters. Bukowska et al. reported significant alterations in foot loading and balance among children aged 11–15 years while carrying school bags, indicating that backpack weight can affect overall locomotor function during this critical developmental period.[18] Conclusion was Previous studies have suggested that children aged 11–15 years are susceptible to gait and postural changes due to backpack loads. Nevertheless, the present study found no significant alteration in step length, indicating that school bag carriage had a limited impact on locomotor function within the study population.
Overall, the findings of the present study agree with the existing literature, indicating that carrying school bags can negatively influence step length and gait characteristics in school-going children. The results support recommendations that school bag weight should be limited to approximately 10–15% of body weight to minimize adverse effects on gait, posture, and musculoskeletal health.[6] conclusion was, The present study demonstrated a slight decrease in step length when children carried school bags; however, the difference was not statistically significant ($p = 0.224$). Therefore, it can be concluded that school bag weight, under the conditions examined in this study, did not significantly affect step length in children aged 11–15 years. Although previous literature reports notable gait alterations with heavier backpack loads, the findings of the present study suggest that the loads carried by participants were insufficient to produce significant changes in this specific gait parameter.

Conclusion

The study concludes that carrying a school bag produced a slight but non-significant decrease in step length among children aged 11–15 years. The observed difference was insufficient to demonstrate a meaningful effect of school bag weight on step length. This suggests that, within the conditions of the present study, school bag load did not significantly alter gait parameter measured as step length.

Limitation of study

- The study was comparative.
- The sample size was small.
- Other important factors affecting gait (e.g., physical fitness, flexibility, and stage of growth) were

not included in the study.

- The number of participants from different age groups and genders may not have been equally distributed, which suggests that the results may not be universally applicable.
- Variations in bag carrying methods (e.g., one shoulder vs. both shoulders) were not controlled.
- Environmental conditions such as walking surface and walking speed were not standardized.
- Children with pre-existing musculoskeletal, neurological, or cardiovascular disorders were excluded.

Future scope of study

- A longitudinal study design is recommended to better evaluate long-term changes in step length and gait patterns with varying school bag weights.
- Future studies should include a larger and more diverse sample population, with balanced representation across age groups (11–15 years) and genders, to improve the generalizability of the findings.
- The use of advanced gait analysis tools (e.g., motion analysis systems, wearable sensors, or digital pedometers) is suggested to enhance accuracy and provide more detailed information regarding step length and walking patterns.
- Further research should consider additional variables such as posture, muscle strength, flexibility, and fatigue to better understand their combined effect on gait.
- Future studies may also compare different types of school bags (e.g., backpacks, sling bags, trolley bags) and carrying methods to assess their impact on step length.
- Investigating the effect of different walking conditions (e.g., stairs, uneven surfaces, and varying speeds) is recommended to simulate real-life scenarios.
- Studies including children with mild musculoskeletal variations could provide broader insight into the impact of school bag weight on gait.

Summary

The present study evaluated the effect of school bag weight on step length in 80 children aged 11–15 years. School bags are an essential part of daily school life; however, carrying excessive loads may influence gait parameters and increase the risk of musculoskeletal discomfort. The purpose of this study was to determine whether carrying a school bag affects step length, an important indicator of gait performance.

A comparative study design was employed, and step length was measured under two conditions: walking without a school bag (0% load) and walking while carrying a school bag. Standardized assessment procedures were used to ensure consistency in data collection. The mean step length without a school bag was 62.5 ± 9.54 cm, whereas the mean step length while carrying a school bag was 61.4 ± 10.95 cm.

Statistical analysis using the paired sample t-test demonstrated a slight decrease in step length when carrying a school bag, with a mean difference of 1.11 cm. However, this difference was not statistically significant ($t = 1.22$, $p = 0.224$). These findings suggest that, although school bag carriage resulted in a small reduction in step length, the effect was not significant among the participants studied.

The study contributes to the understanding of how school bag loads may influence gait characteristics in school-aged children. Limitations of the study include the assessment of a single gait parameter and the absence of control over factors such as physical activity level, body composition, and duration of bag carriage. Future research should involve larger sample sizes, different load percentages, and comprehensive gait analysis to further investigate the biomechanical effects of school bag weight on children.

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